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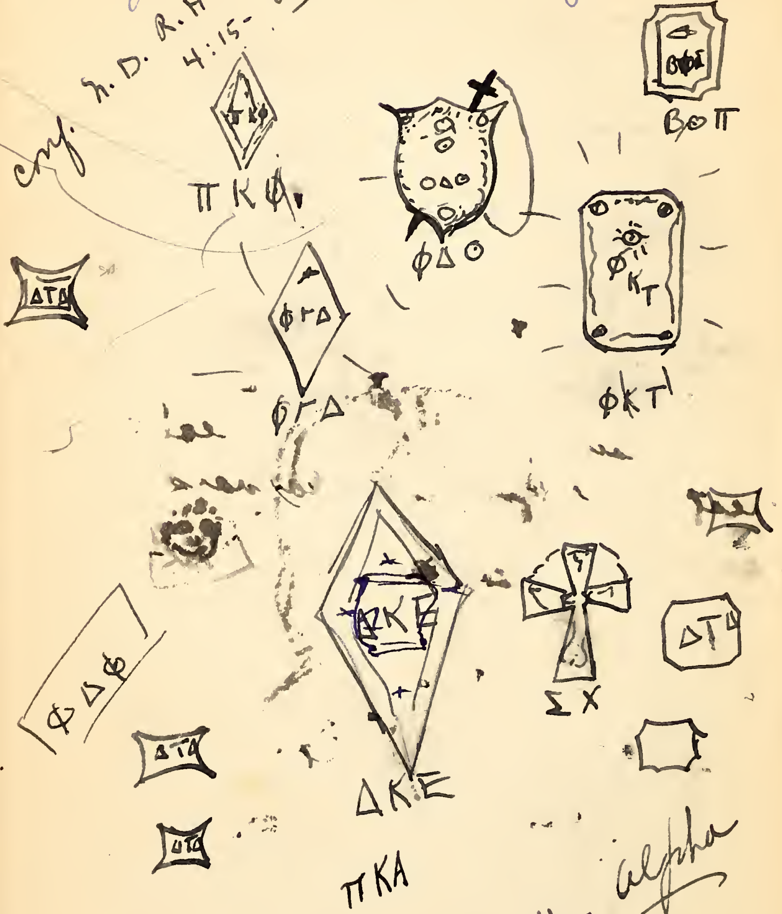

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# EDUCATIONAL PSYCHOLOGY

# TEACHER TRAINING SERIES

Walter S. Monroe, General Editor

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Monroe: directing learning in the high school

Monroe and Weber: the high school

Monroe, DeVoss, and Reagan: educational psychology

James Marvin Jones Jr

# EDUCATIONAL PSYCHOLOGY

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# PREFACE

The present volume, *Educational Psychology*, and the two volumes previously published, *Directing Learning in the High School* and *The High School*, form a series of texts designed for the three basic courses in the training of secondary teachers—educational psychology, methods of teaching, and principles of secondary education. There is little overlapping of content in these three volumes, and when overlapping does occur, it is because the authors considered the duplication of content desirable. The authors have endeavored throughout the series to be consistent in the use of technical terms and to conform to the same general philosophy of education.

The value of a coördinated series of texts for the three basic courses in the training of teachers should be apparent. For the most part, texts for these courses have been prepared, hitherto, by three groups of writers working independently. Texts on educational psychology have been written by specialists in that field who gave little consideration to the content of texts on methods of teaching; writers in the field of methods have not articulated their texts with those on educational psychology and have exhibited considerable variation in the selection of the topics treated as well as in the elaborateness of treatment; the authors of texts dealing with the principles of secondary education and its organization have invaded both educational psychology and methods of teaching and also have introduced technical administrative topics. Considered separately, a number of the texts possess much merit, but frequently a combination of texts selected for the basic courses exhibits undesirable overlapping in content as well as disturbing variations in terminology and points of view.

Although this volume has been prepared as one unit of a series it may be used independently of the two other volumes. Furthermore, its usefulness is not limited to the training of secondary teachers. Most of the topics of educational psychology apply to the elementary school as well as to the high school.

In the introductory chapter it is pointed out that the content of educational psychology is far from being standardized. Consequently, in writing a text, the author faces the difficult problem of deciding upon the topics to be treated and the relative emphasis to be given to those included. In writing this volume the authors have attempted to prepare a text that will be an effective instrument for the training of teachers, rather than to promulgate any new psychological theory or to present an encyclopedic summary of the results of investigations in the field of educational psychology. This policy has resulted in omitting or minimizing some topics that other authors have included or treated more comprehensively. On the other hand certain topics have been given a more extended treatment than is to be found in other texts. A few topics have been included which may be described as "new." Whether the present writers have judged wisely in determining the content can be determined only by the effectiveness of the text as an instrument for the professional training of teachers.

The general plan of the text is described in the Introduction and need not be repeated here. The number of chapters has been restricted to fifteen. This was thought to be a wise plan of organization since the student's attention will be focused upon a relatively few groups of related topics. Numerous cross-references, especially in the later chapters (as well as references to the other volumes in the series) should aid the student in integrating his learning. The Learning Exercises for the Reader which appear at the ends of the several chapters are intended to be an integral part of the text. The present writers believe that a student's reading of the text and his participation in the discussions of the classroom should be supplemented by other types of learning activity, and it is hoped that the learning exercises will serve as an efficient basis for this needed supplementation.

Although this volume is intended as a text for a first course in educational psychology, portions may appear to be somewhat difficult for this purpose. The authors believe this characteristic of the book to be an asset rather than a liability. In view of the individual differences that exist in classes of prospective teachers, it is desirable to have some material in a text difficult enough to afford a challenge to the brighter students. In the case of the less capable students it is desirable to have them realize that they have not attained a mastery of educational psychology when they have comprehended some of the easier topics of the field. An instructor using the text may decide not to require a thorough study of some of the more difficult portions; he may omit them altogether. This practice is likely to be desirable when the class consists of college freshmen. Even when omissions are made, however, it is usually advantageous for the students to have in their hands a text that goes beyond the minimum objectives set for the course.

The reader will observe that the authors are heavily indebted to many writers. Specific acknowledgments of this indebtedness are made by references to sources, but it is difficult, if not impossible, to give credit for the general stimulation and guidance derived from the writings of Freeman, Judd, Thorndike, Woodworth, and other authorities. The authors are also indebted for criticism and suggestions to Dr. E. F. Pothoff, University of Illinois, and Dr. Ruth Streitz, University of Cincinnati, who have read the manuscript.

Walter S. Monroe
James C. DeVoss
George W. Reagan

January, 1930.

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# EDUCATIONAL PSYCHOLOGY

# EDUCATIONAL PSYCHOLOGY

## CHAPTER I

## INTRODUCTION

**The meaning of education from the point of view of psychology.**—A human being is a very elaborate and complex mechanism that responds or reacts to sounds, visual stimuli, odors, heat, pressure applied to the surface of the body, and the like. This activity of responding we call behavior. The response a person makes to a given stimulus is not a random reaction. It is determined by the status of his physical mechanism. An educated person is identified by his behavior, that is, by the way he acts and thinks. His behavior is different from that of one who is uneducated. This difference is due to differences in their respective physical mechanisms.

The psychologist thinks of education[1] in terms of the production of changes in human beings (usually children) that will make their behavior different from that which would have prevailed in the absence of education. Although he usually specifies that the changes produced shall be useful or conform to certain requirements, the psychologist is only secondarily concerned with what these changes *should* be. In other words, he is interested in the *process* of education, rather than the ultimate purposes to be attained. The determination of the purposes of education is the responsibility of the philosopher or the educational theorist. But the psychologist does seek to understand the nature of the changes to be produced and how they function in modifying and controlling behavior.

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[1] "Education" is used here with a general meaning. It is not restricted to "schooling" but includes all experience that is educative.

**The central problems of educational psychology.**—When subjected to stimuli[1] of certain kinds, the child responds—that is, activity goes on within the mechanism. The child, however, is more than a mere machine; for, unlike the machine, he possesses the quality of being changed by the responses which he makes. The teacher's task is to encourage, stimulate, and direct the child so that the resulting activity will be educationally efficient. It is obvious that in order to go about this task in an intelligent manner, the teacher needs to know the child—the nature of the mechanism and its reactions to stimuli, and the ways in which it matures and is changed by its own activity.

The central problem of educational psychology is expressed by the question, *How do children learn?* Preliminary to the study of this problem, however, it is necessary to consider the following questions:

1. What is the nature of the physical mechanism involved in learning?
2. How does this physical mechanism react to stimuli?
3. What is the nature of the controls of human behavior and how do they operate?

Educational psychology is not as simple nor as limited as these few questions may suggest to the reader. Each of them may be analyzed into a group of subordinate questions. Furthermore, children differ, and it is necessary to consider how they learn at different levels of maturity, training, and intelligence. Other problems will doubtless occur to the reader, especially in class discussions. For example, Where did Roy get his sense of humor? Is it inherited or did he learn it from his parents? Can it be increased or refined or diminished? Why do some children make little progress in their school work? Is there anything teachers or society can do to accelerate their progress? What children are on their way to become criminals, hobos, prostitutes, paupers, or failures of other kinds? What program of education will salvage these to good citizenship? Harry asks, "For what occupation should I prepare myself?" What information is needed to give him the best possible answer? What traits, interests, and capacities in a boy of ten will insure that he may become a successful doctor? Or can such questions be answered for ten-year-olds? If not, can fits and misfits be detected in the junior high school, in the senior high school, or in the junior college? Are musicians always poor in mathematics and good in language studies? Do good mathematicians tend to be good in science?

---

[1] A stimulus is anything to which the child reacts—light waves, sound waves, chemicals, pressure, heat, cold, etc. A complex group of stimuli is usually designated as a situation.

These problems are but random samples. For many such problems, the educational psychologist has no answer, or at best only a plausible hypothesis. The student who is curious concerning human nature will encounter questions that challenge him to further study. This volume, being designed as a text for a first course, does not presume to attempt to consider all possible questions. Its scope is intentionally restricted.

**The content of current texts on educational psychology.**—The preceding description of educational psychology represents the present writers' concept of a first course in the subject. They are aware that authorities disagree in regard to the topics that should be included. Examination of current texts on educational psychology reveals marked differences in content. One investigator has reported that "judging from the amount of space given to definite topics" the two most widely used texts, Gates[1] and Starch,[2] "agree to the extent of only about 33 per cent."[3] After examining three other widely used texts this writer concludes: "In fact, one would be somewhat put to it to discover five texts on supposedly the same subject that vary more than do these."

Such variations in content are doubtless due in part to the fact that educational psychology is a young and growing professional subject. Time is required to select and organize the content of a subject. The large number of investigations being reported in educational periodicals and in monographs and bulletins is evidence of the growing state of this field. Under the circumstances it is natural that current texts exhibit variations in content. This lack of agreement in content is probably augmented by the tendency of workers within a field to develop specialized interests. For example, a specialist in intelligence testing would be likely to emphasize this topic much more than another writer who had studied intensively the topic of perception.

**The point of view of the present writers.**—In view of this chaotic condition an author of a text on educational psychology must make his own determination of the topics to be treated. In determining the content of this volume the present writers have attempted to keep in mind the function of a first course in educational psychology in training prospective teachers, and to include only those topics that appear highly important for this purpose. This policy has doubtless resulted in the omission of much material that is interesting to psychologists and other persons who are curious about human beings. The present writers, however, believe that the student pursuing a first course in educational psychology is only confused by a multiplicity of details, and that there is ample justification for a text restricted to the topics selected for discussion in this book.

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[1] Gates, A. I.—*Psychology for Students of Education.* New York: The Macmillan Company, 1923. 489 pp.

[2] Starch, Daniel.—*Educational Psychology.* New York: The Macmillan Company, 1919. 473 pp.

[3] Worcester, Dean A.—"The Wide Diversities of Practice in First Courses in Educational Psychology," *Journal of Educational Psychology*, 18:14, January, 1927.

**The historical trend of educational psychology.**—Although educational psychology is new as a field of study in teacher-training institutions, history records many attempts to answer some of the questions noted in the preceding pages. During the nineteenth century educational practice in the United States was based upon a theory of learning which is commonly called the "doctrine of formal discipline." This concept of the learning process was accompanied by the belief that a person's mind consisted of certain "faculties" or "powers"—such as observation, memory, imagination, judgment, and reason. Education was the process of developing and training these powers.[1] Mental arithmetic, Latin, and formal grammar

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[1] "The discipline of the mind, then, is the great thing in intellectual training; and the question is not, how much have I acquired? but, how have my powers been strengthened in the act of acquisition?" PAGE, D. P.—*Theory and Practice of Teaching.* New York: American Book Company, 1885, p. 97. Originally published 1847.

". . . the developing of power should be made the leading aim of teaching. Knowledge is necessary to enlighten and guide in all human effort, but mental power gives acumen, grasp, strength, poise, inspiration, and these are the were considered to possess a high educative value because it was believed that these subjects were an excellent means for training the mental powers or faculties. During this period educational psychology was unknown as a subject of instruction, but texts on "pedagogy" included a number of the topics that we now associate with this field.

Our present educational psychology did not grow directly from any one line of investigation or interest. It is the culmination of activities in several fields of endeavor. Some of them began to gather real headway during the early part of the nineteenth century. Both Comenius and Pestalozzi had taught that education should follow the course of the child's natural development and should have as its basis the laws of mental development. Herbart, with more understanding of these laws, added his word that education can never be properly organized on any other basis. DeGarmo and the McMurrys, students of Herbart's theories, brought to America the five formal steps of teaching procedure and the culture epoch theory.[2] The latter was an invitation to researches into both child life and the lives of primitive people. The five formal steps constituted a challenge to the curious educator and later to the new laboratory psychology which Hall and Cattell brought from Germany in the '80s. From these beginnings, after much experiment and discussion, has come the understanding that for edu-

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winners of success in all the duties of practical life. . . . If my mind were a tablet, and with a sponge I should erase every fact learned in school and college, and not directly applied in the arts there acquired, I should not be very poor, but were I to lose the mental power gained by the mastery of these facts, so many of which were long since forgotten, I should be poor indeed." White, E. E.—*The Elements of Pedagogy.* New York: Van Antwerp, Bragg and Company, 1886, p. 123.

[2] See page 408.

cation the child's capacity for learning is of first importance; it is education's opportunity. Before education can take full advantage of this capacity, the nature of the learning process must be understood, the laws of learning must be formulated, and the variations in the capacities of individual children must be measured and stated in convenient and precise terms.

These objectives have not been fully realized, nor was the progress we now recognize made at once. The hopeful student of education, having grasped the principle that the laws of mental development are basic to education, looked first to psychology for their discovery and statement. Laboratory psychology was thought to promise much. Cheered by the apparent success of the German laboratories, American psychologists had set up more laboratories by 1905 than there were universities in all of Europe. Strangely enough, it was laboratory studies with animals as subjects which gave the first contributions. Thorndike published his results in *Animal Intelligence* in 1898, and in *The Mental Life of Monkeys* in 1901. "Learning by trial and error," "law of readiness," "law of exercise," and "law of effect"[1] are terms and concepts which date from this early work. A great deal of the laboratory psychology has been sterile of results that could be applied to education, but some of the materials and methods of the laboratory have been taken over by the makers of educational and intelligence tests.

The testing movement, which is a very important development in educational psychology, has a history so varied and extensive as to require more space than this chapter can supply. It would take us back along the course of development of interest in, and care for, the feeble-minded and the insane. Down another road, it would lead us to investigate the beginnings of genetics and statistics with Galton and his followers.[1]

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[1] These laws are discussed in Chapter V.

Man's native endowment has long been a center of controversy. From the time of Darwin and his great disciples, Huxley and Spencer, there has been earnest and often heated argument concerning the origin and order of appearance of native traits. This controversy is connected with the recurring debate concerning the validity of the hypothesis of evolution, and much that has been said is sterile, with a definite theological tinge. Within the ranks of the scientists it has taken the form of a debate on the relative potency of nature and nurture in mental development.[2] More recently the usefulness of the term "instinct" and the existence of unlearned tendencies have been questioned. The limitations that are placed upon the more general capacities by inheritance have been the subject of current controversies, with the questions relating to the nature of intelligence and its rate of development in the foreground.

For a time it appeared that the genetic aspect of psychology would dominate the field of educational psychology. Of all the movements that grew out of the interest in the theory of evolution, that of child study was for a time most active. Its intimate relation to evolution is attested by the fact that Darwin made the first systematic study of a child's mental development. G. Stanley Hall[1] was the leader of this movement in America. From the publication of *The Contents of a Child's Mind on Entering School*, in 1891, until the middle of the second decade of this century, Hall and his students were very productive of studies of the interests, activities, and the various characteristics of childhood. Their chief method, that of the questionnaire, fell into disrepute with the rise of more objective methods, but the child-study movement made a real contribution to educational psychology. If its force had been spent when it aroused a widespread interest in the peculiar needs of childhood, it would have abundantly justified the time and energy devoted to it. It involved a principle which the modern educational psychologist often violates. Because college students and other adults are more available than children, too many of our laboratory studies, especially those of learning, have used adult subjects; too few have used children. Although principles of learning may be discovered in experiments with animals and adult human beings, they need verification by research with children.

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[1] Every student of educational psychology should know the reasons for the prominence of such names as Galton, Binet, Cattell, Rice, Thorndike, Stone, Courtis, Goddard, and Terman. Phases of the work of these men are described in later chapters, especially Chapters VIII and IX on the measurement of intelligence and achievement.

[2] This topic is discussed at several places in the following chapters. See pages 255f and 356f.

**Educational psychology systematized by Thorndike.**— Educational psychology as a coherent and organized subject dates from the publication of Thorndike's three volumes in 1914.[2] In his introduction, Thorndike pays well-deserved tribute to the three great Americans in this field: Hall, Cattell, and James. Elsewhere he recognizes the work of such foreign leaders as Binet in France, Galton in England, and Ebbinghaus and Meumann in Germany.

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[1] HALL, G. S.—*Life and Confessions of a Psychologist.* New York: D. Appleton and Company, 1923. 623 pp.

[2] The titles of these volumes are (1) *The Original Nature of Man*, (2) *The Psychology of Learning*, and (3) *Work, Fatigue, and Individual Differences.* (See reference on page 20.)

James had given us his *Talks to Teachers* (1899), Hall followed with his monumental *Adolescence* (1904), and Judd had written his excellent *Genetic Psychology for Teachers* (1907). Though these works had merit and each was prophetic of development in its field, Thorndike systematized the subject for American students.

**Recent developments in educational psychology.**—Information concerning the emotions has accumulated very slowly. As education has become more socialized and as social participation has been increasingly emphasized in classroom teaching, appropriate training of the emotions has become recognized as a fundamental need. This training has been emphasized by the literature bearing on mental hygiene. When we compare the appeals made by the two topics, "The Psychology of the Emotions" and "Mental Hygiene," it becomes evident that the latter topic has been made to include the information furnished by the discussions introduced by both topics. Thus mental hygiene includes a consideration of the laws governing the engendering of fears, prejudices, ideals, enthusiasms, loyalties, sentiments, suspicions, and a host of other attitudes.

During the past fifteen years, the measurement of intelligence has been gaining ground in its popular appeal and in its application to the problems of education and industry. It has furnished far more than its quota of controversies. To avoid these controversies would be to overlook some of the richest material in our recent educational literature. To settle these controversies is beyond our powers, but there are appearing certain tendencies and some results which indicate that the measurement of intelligence is finding its true place. Only a few of the problems which have been referred to the psychological examiner can be solved by the use of tests of intelligence.

The tests of intelligence represent the most numerous but by no means the only tests of general abilities. There are now tests of mechanical ability, tests of social intelligence, tests of temperament, and the beginnings of tests of other traits.

**The relation of educational psychology to the total field of psychology.**—Educational psychology is obviously a division of the total field of psychology. In general terms it may be described as that portion of the total field which relates most directly to the education of children. Its boundaries are somewhat vague, but this is also true of other specialized psychologies—animal psychology, abnormal psychology, comparative psychology, genetic psychology, social psychology, etc. If a number of authorities were asked to specify the scope of the field of educational psychology, their replies would vary in the topics enumerated. Some would include a wide range of topics, invading the field of methods of teaching, phases of school administration such as educational and vocational guidance, and educational statistics; other authorities would describe a much more restricted field.

Educational psychology is probably best described in terms of what educational psychologists are doing. It appears that many educational psychologists make excursions across the boundaries into other fields, but it would be a low-spirited scientist who would be content merely with discovering facts, and who would deprecate the application of them to education when there are so many gaps in our knowledge of human nature that it seems to be the great *terra incognita* of science to-day. The educational psychologist must be an explorer much of the time. At present the pure psychologist seems more interested in making explorations into the common characteristics of human beings; the educational psychologist is more often interested in investigating their individual differences. If we press this inquiry further, we shall find that the discussions of educational psychology include material from the social sciences, from the natural sciences of biology, physiology, and neurology, from statistics, from physics and chemistry, from anthropology, and from ethnology. In so far as this material is of aid in the description of human traits and their modification, it becomes subject matter for educational psychology.

Since the boundaries of this subject are instable, precise definition is manifestly impossible and undesirable. Educational psychology is a quest, not an estate or principality. As long as it is sensitive to the progress of researches in other fields of endeavor, there is hope for its continued growth.

**The methods of educational psychology.**—In attempting to answer the problems of educational psychology, the psychologist employs two principal methods of securing information. He *observes* his own mental activity and the behavior of other persons and animals. The observation by a person of his own mental activity is called *introspection* or "*subjective observation*." By means of this method he may review and study his own consciousness. For example, a person is asked a question and after thinking it over he gives an answer. Later he may recall the various ideas that came into his mind as he thought over the question; and as he reviews his mental experience, he may be able to explain why these ideas came into his mind instead of others, and how he arrived at the answer he gave to the question.

It is impossible to observe directly the mental activity of another person. We can observe only his overt behavior.

This method, which may be called "*objective*[1] *observation*," has certain obvious advantages over introspection. In the first place the introspectionist can study directly only himself; by using the method of "objective observation" the psychologist can study as many subjects as he pleases. Furthermore, two or more psychologists may observe the behavior of the same subjects. For these reasons and because instruments and techniques have been developed, "objective observation" yields more dependable information than introspection, but it is significant to note that mental activity can only be inferred from behavior. A pupil's answer to a question may include little or no indication of how he arrived at it.

A great deal of "objective observation" is being accomplished by means of educational tests. The person tested is asked to respond to certain exercises and his score is the examiner's description of his performance. Experimentation is also a method of "objective observation." In a psychological experiment a subject or group of subjects are subjected to certain conditions or influences for a period and the change in their behavior noted. For example, in a learning experiment a subject may be required to practice a certain exercise such as typing a given selection thirty minutes a day for a period of fifty days. The effects of this training are "observed" by administering suitable tests at the beginning and at the end of the period.

One advantage of "objective observation" is obvious.

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[1] The adjectives "subjective" and "objective" are sometimes sources of confusion because different writers do not agree in regard to their meaning. As used in this volume, "subjective" means capable of being influenced by the investigator, and "objective" means removed from or not influenced by the bias or prejudice of the investigator. When applied to data collected, "subjective" does not mean inaccurate but simply indicates a possible source of error. Likewise "objective" does not mean accurate data but simply that one source of error has been eliminated or greatly minimized.

In introspection a psychologist's observations may be biased by his beliefs, and verification is not possible. When the observation is "objective" the findings may be verified, and, more important, instruments may be employed to secure highly reliable information. For example, the motion picture camera has been used for photographing the eye movements of readers. Some writers[1] take the position that introspection cannot be considered a scientific method and hence maintain that only objective methods are justifiable if we wish to develop educational psychology on a scientific basis.

**Educational psychology as a science.**—The brain, spinal cord, and some of the larger nerves are observable when an animal is dissected. By the aid of a microscope it is possible to observe a neurone[2] and its structure. A nerve impulse cannot be observed, but laboratory studies of frogs and other animals have yielded evidence that supports the hypothesis of something flowing along a neurone and passing into another neurone or a group of neurones. A nerve impulse, therefore, is a hypothetical concept formed as an explanation of observed phenomena. Consciousness, also, is not observable and a person can know directly only his own consciousness. He may observe the performance of another person and make inferences in regard to his consciousness, but an observer is always compelled to guess in regard to the content and quality of the consciousness of another. As the result of painstaking inquiry by psychologists, we now have a body of facts which justify the belief that many of our hypotheses are correct or approximately so. On the other hand, there is much about functioning of the nervous system and about consciousness that we do not know as yet. In such cases, we have only hypotheses, some of them supported by only circumstantial evidence.

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[1] For example, see SANDIFORD, PETER—*Educational Psychology.* New York: Longmans, Green and Company, 1928, pp. 4f.

[2] For explanation of this term, see page 25.

Educational psychology is not a mature science. Although we have made a very respectable beginning, we have much to learn. Meanwhile, teachers need a working understanding of the child. Due to the immaturity of psychological science, psychologists differ in regard to the hypotheses made to explain the behavior of children. This situation makes it necessary for the author of a text for teachers to select from the various hypotheses those that appear most helpful to them. Although an author should not be neglectful of the requirements of a science, his principal obligation is to furnish teachers with a maximum of useful information and hypotheses relative to the central questions listed on page 2.

**Schools of psychology.**—The necessity of making hypotheses in regard to the functioning of the nervous system and mental activity naturally creates an opportunity for differences of opinion. Those psychologists who accept a group of hypotheses form a "school of thought" and create a psychology that tends to be unique. Hence we have "consciousness psychology," "behavioristic psychology,"[1] "Gestalt psychology,"[2] and the like. In addition to the relatively distinct schools of psychology, there are various combinations.

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[1] Watson, J. B.—*Psychology from the Standpoint of a Behaviorist.* Second Edition. Philadelphia: J. B. Lippincott Company, 1924. 448 pp.

[2] Humphrey, George.—"The Psychology of the Gestalt," *Journal of Educational Psychology*, 15:401–12, October, 1924.

Koffka, Kurt.—(Translated by R. M. Ogden.) *The Growth of the Mind.* New York: Harcourt, Brace and Company, 1924. 383 pp.

Köhler, Wolfgang.—*Gestalt Psychology.* New York: Horace Liveright, Inc., 1926. 403 pp.

Ogden, R. M.—*Psychology and Education.* New York: Harcourt, Brace and Company, 1926. 364 pp.

The different points of view or schools of thought need not concern the student in a first course in educational psychology. He should be aware that different schools exist; but it does not appear desirable to understand each of them. The point of view of the present writers is eclectic. They agree with the behaviorists in part, but they also believe that the method of introspection may be employed and that it is necessary to give attention to conscious processes.[1]

**The relation of educational psychology to methods of teaching.**—The facts about mental activity and the laws of learning do not specify the procedures that a teacher should employ in stimulating and directing the learning activities of children. In his *Talks to Teachers* James pointed out that "you make a great, a very great mistake, if you think that psychology, being the science of the mind's laws, is something from which you can deduce definite programs and schemes and methods of instruction for immediate schoolroom use."[2] While it is obvious that the techniques used by the teacher in stimulating and directing the learning activities of children should be compatible with the nature of the learning process, and furthermore, though it appears reasonable to say that psychological facts and hypotheses should be utilized as a basis in devising and selecting instructional procedures, yet educational psychology cannot determine methods of teaching.[1] Since this volume is a text in educational psychology there will be no systematic attempt to point out the applications to methods of teaching.[2]

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[1] The reader who is interested in psychological theory will find it helpful to consult Bode, B. H.—*Conflicting Psychologies of Learning.* Boston: D. C. Heath and Company, 1929. 305 pp.

[2] James, William.—*Talks to Teachers on Psychology: And to Students on Some of Life's Ideals.* New York: Henry Holt and Company, 1900, p. 7.

**The place of educational psychology in the professional training of teachers.**—It is obvious that educational psychology occupies a strategic position in the professional training of teachers.[3] As pointed out in the beginning of this chapter, the teacher needs to understand children in order to perform his task intelligently. He cannot be efficient as a director of learning unless he understands the learning process. Educational psychology, however, cannot satisfy the total need for professional training. It should be followed by a course in methods of teaching and one in which the prospective teacher can become acquainted with the purposes of the school, its organization, its relation to the community, and something of its history. Such a course is usually offered for teachers preparing for the secondary level. It is designated by a variety of titles of which "Principles of Secondary Education" is probably most common.[1] A similar course is needed for the elementary school.

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[1] Goodwin B. Watson has reported an interesting experiment in which he attempted to ascertain the effect of making educational psychology more practical by the use of "unusual abundance of illustrations in connection with teaching." This procedure seemed to produce very little change in the ability of the students to "analyze teaching situations."

Watson, G. B.—"A Comparison of Two Types of Illustration for Teaching Educational Psychology," *Journal of Educational Psychology*, 18:433–44, October, 1927.

[2] This has been done for the high-school level in another volume. See Monroe, Walter S.—*Directing Learning in the High School.* Garden City, New York: Doubleday, Doran and Company, Inc., 1927. 577 pp. A second volume dealing with methods of teaching in the elementary school is in preparation.

[3] For reports of attempts to determine the relative value of the major divisions of educational psychology see Watson, G. B.—"What Shall Be Taught in Educational Psychology," *Journal of Educational Psychology*, 17:577–99, December, 1926, and Hertzberg, O. E.—"The Opinion of a Teacher-Training Institution Concerning the Relative Value of Subject Matter in Educational Psychology to the Elementary School Teacher," *Journal of Educational Psychology*, 19:329–42, May, 1928.

These three courses—educational psychology, methods of teaching, and principles of education—may be designated as basic in the professional training of teachers. Students who expect to become principals, superintendents, or supervisors need to pursue courses pertaining to these positions, but such courses are not basic in the work of the teacher. Teacher training departments usually offer other courses for teachers, most of them being more extensive and sometimes more intensive treatments of topics included in what we have called the basic courses.

**How to study this text.**—In writing this text the authors have assumed that the student would do a number of the learning exercises that are given at the end of the several chapters, or similar exercises assigned by the instructor. Learning is an active process and what a student learns will result from his own activity, not from what the authors may include in the text nor from what the instructor may say during the class period. If the student expects to learn, he must be active. Reading the text should be supplemented by other activities, and the authors believe that the learning exercises afford bases for effective learning activities.

The study of the text should be more than mere reading. Most of the following pages are designed to be read carefully and critically. Although the student should add a number of new words and phrases to his speaking and especially to his thinking vocabulary, the most important thing to be attained is an understanding of the learning process and the allied topics so that the student may be able to answer *thought* questions—that is, that he be able to apply what has been learned. In fact, the student should not consider that he has learned in the true sense of the term until he is able to apply his knowledge.

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[1] The content of this course is represented by MONROE, WALTER S., and WEBER, OSCAR F.—*The High School.* Garden City, N. Y.: Doubleday, Doran and Company, Inc., 1928. 511 pp.

**The technical vocabulary of educational psychology.**—Some of the technical terms used in the following chapters will not be new to the reader but he may find that they are used with a more precise meaning than he is accustomed to. A number of words and phrases will probably be new. It is highly important that the reader associate clear and definite meanings with all technical terms. The number of such terms is probably in excess of two hundred.[1]

**The plan of the following chapters.**—The nervous system and certain other phases of the human mechanism are described in Chapter II in order to provide a basis for understanding the treatment of some of the later topics. Chapters III to VII are devoted to the functioning of the physical mechanism, the learning process, and its outcomes. The measurement of intelligence and achievement is considered in Chapters VIII and IX. From one point of view Chapters III to VII form the core of the text, but in them there is little recognition of individual differences or of the nature of children at different ages. These two topics are treated in Chapters X and XI. The remaining four chapters of the book are review chapters. In Chapters XII and XIII the psychology of certain school subjects is considered. Chapter XIV is devoted to the topic of mental hygiene and the final chapter deals with the topic: How to study children.

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[1] One teacher of psychology has reported that a check for several years revealed "approximately two hundred technical terms which must be 'learned' by students of psychology before they have finished their study of the subject." HARLAN, C. L.—"The Technical Vocabulary of Psychology." *Journal of Educational Psychology*, 17:554, November, 1926.

## A REFERENCE LIBRARY FOR SUPPLEMENTARY READING

The following books have been selected as a reference list for supplementary reading. If an instructor using this volume as a basic text believes that certain topics deserve a more extended treatment, he may assign readings from the following list. A number of supplementary readings are suggested in footnotes in the following chapters and others are given in the "Learning Exercises for the Reader" at the end of the several chapters.

Cameron, E. H.—*Educational Psychology.* New York: The Century Company, 1927. 467 pp.
Carr, H. A.—*Psychology.* New York: Longmans, Green and Company, 1925. 432 pp.
Freeman, F. N.—*How Children Learn.* Boston: Houghton Mifflin Company, 1917. 322 pp.
Freeman, F. N.—*Mental Tests.* Boston: Houghton Mifflin Company, 1926. 503 pp.
Gates, A. I.—*Psychology for Students of Education.* New York: The Macmillan Company, 1923. 489 pp.
Gault, R. H., and Howard, D. T.—*Outline of General Psychology.* New York: Longmans, Green and Company, 1925. 474 pp.
James, William.—*Psychology, Briefer Course.* New York: Henry Holt and Company, 1892. 478 pp.
Judd, C. H.—*Psychology of Secondary Education.* Boston: Ginn and Company, 1927. 545 pp.
McDougall, William.—*Outline of Psychology.* New York: Charles Scribner's Sons, 1923. 456 pp.
Sandiford, Peter.—*Educational Psychology.* New York: Longmans, Green and Company, 1928. 406 pp.
Starch, Daniel.—*Educational Psychology.* New York: The Macmillan Company, 1927. 568 pp.
Thorndike, E. L.—*Educational Psychology*, Vols. I, II, and III. New York: Teachers College, Columbia University, 1913–14. 327 pp.; 452 pp.; and 408 pp.

WARREN, H. C.—*Human Psychology*. Boston: Houghton Mifflin Company, 1919. 460 pp.
WOODWORTH, R. S.—*Psychology*. New York: Henry Holt and Company, 1921. 580 pp.

## LEARNING EXERCISES FOR THE READER

1. What is the peculiar function of each of the following relative to the educative process: (1) the educational theorist, (2) the educational psychologist, (3) the educational administrator, (4) the methodologist, (5) the classroom teacher?
2. What is the relation of educational psychology to general psychology?
3. What do you understand to be meant by the statement: "Educational psychology is a quest, not an estate or principality"?
4. What is the difference between a theory or hypothesis and a law? What is the place of the former in science? (Consider the atomic theory or the ether theory.)
5. What is meant by saying that education must be based upon the laws of mental development?
6. How may the wide variation in the contents of texts in educational psychology be explained?
7. Discuss the relative merits of introspection and objective observation as methods of psychology.
8. Comment on James' statement: "Psychology is a science and teaching is an art." What is the distinction between a science and an art?
9. Make a list of the psychological terms used in this chapter. Do you understand all of them?
10. Why is the psychologist more interested in how children learn than in what they learn?
11. Examine the tables of contents of two or three other texts on educational psychology and note how they differ from that of this volume.
12. Read the description of the methods of psychology in GATES.—*Psychology for Students of Education*, pp. 1–10.
13. The contribution of Thorndike to educational psychology was referred to on page 9. Consult the *Teachers College Record*,

27: 458–86, February, 1926, for an annotated bibliography of his writings and an evaluation of his contributions.

14. Read Judd, C. H.—"A Century of Applications of Psychology to Education," *Teachers College Record*, 27:771–81, May, 1926. This is an especially stimulating article.

# CHAPTER II

## THE PHYSICAL MECHANISM

*Note to the reader.*—This chapter includes a large number of details about the nervous system and the other divisions of the physical mechanism which are relatively unimportant with reference to the course in educational psychology. It has, however, seemed desirable to include them in order to provide for readers who have not studied general psychology. In studying this chapter it will not be necessary for the reader to attempt to memorize the details of structure. He should, however, make certain that he comprehends the general plan of the physical mechanism and the way in which it functions.

**The problem of Chapter II.**—This chapter deals with the second of the four questions listed on page 2. In describing the physical mechanism involved in human behavior, attention is focused upon its structure, but there will necessarily be some reference to its functioning. This topic, however, is taken up more systematically in later chapters, especially Chapter III.

**Divisions of the physical mechanism.**—For our purpose it is helpful to think of the physical mechanism of human beings in terms of three divisions:

I. The *receptors*, which consist of specialized cells that are sensitive to certain stimuli. The more commonly used term "sense organs" has approximately the same meaning but the receptors for some sensations are too simple in structure to be called sense organs. For this and other reasons, "receptor" should be used when precise statements are desired.

II. The *connectors*, which include the brain, the spinal cord, and the nerves leading to and from these divisions of the nervous system.

III. The *effectors*, which consist of the muscles and the glands.

These three divisions will be described in the order named, but it will be helpful to note the general structure of the nervous system preparatory to the more detailed consideration.

**The general plan of the nervous system.**—The nervous system includes three groups of neurones. One of these groups originates in the receptors and ends in the brain and other connecting centers. Another set originates in the centers of connection and ends in the muscles and glands. The connecting neurones form a third group. The stimulation of a receptor produces a nerve impulse that travels along the sensory neurone affected. When the end of this neurone is reached, the impulse passes to another, usually one in a connecting center, and finally on to one ending in a muscle or gland. The neurones may be functionally classified as:

1. Sensory, or afferent
2. Association, or central
3. Motor, or efferent

Obviously the afferent neurones are those which carry nerve impulses from receptors toward the central nervous system. The association neurones then take up the impulses and in some way determine what motor or efferent neurones shall receive them for transmission to the muscles or glands.

**Neurones, the unit of the nervous system.**—The true nerve cell, which is the structural unit of the nervous system, is called a *neurone.* There are other cells in the nervous system, such as neuroglia fibers, ependyma, glia cells, and blood cells, and possibly others, but the neurone is the cell without which the nervous system could not perform its peculiar function. Neurones are able to receive, conduct, and discharge nerve impulses more readily than any other cells of the body. Three types of neurones—motor, sensory, and association—are shown in Figure 1. The significant characteristics are the *cell body* with its nucleus and

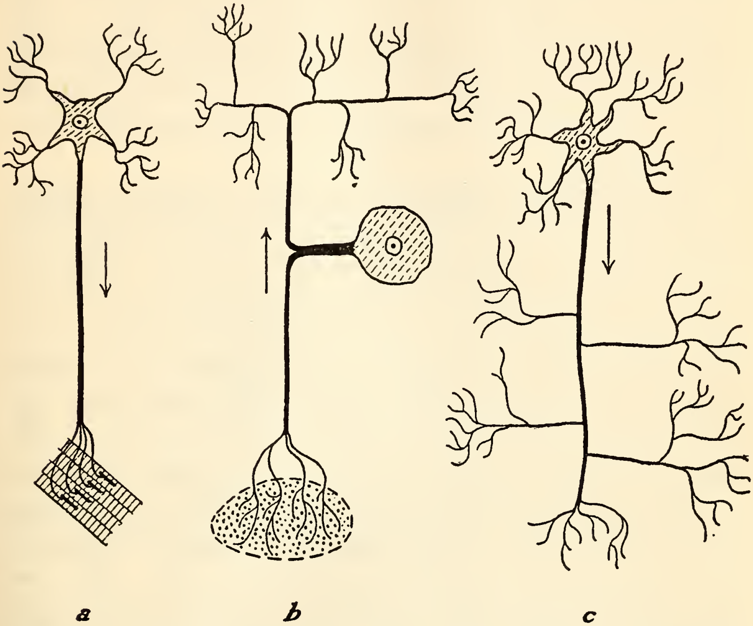

Figure 1. Diagrammatic Representation of Types of Neurones. a, motor neurone; b, sensory neurone; c, association neurone.

one or more of each of two kinds of processes or branches. One of these is tree-like and is appropriately called the *dendrite*. Usually the dendrite is on the receiving end of the neurones. The other type of process is on the sending end of the neurone and is called *axon*, sometimes *axis cylinder* or *neurite*. At its extremity and often at the extremities of the branches, an axon arborizes or branches out into an end brush for contact with the muscle or gland cell, or for functional connection with the dendrite of another neurone.

The preceding paragraph describes a typical neurone, but neurones are not much more typical than people. In Figure 1a, the dendrites at the upper end are typical in form. The axon without branches is also typical in form and both dendrites and axons are typical in function as the arrows indicate that the nerve impulse has entered through the dendrites and will leave the axon going out through the end brush and end plates to the muscle cell. Figure 1b shows a diagram of a neurone which does not conform to the general description. This is a sensory neurone like many which connect the somatic receptors with the sensory neurones of the spinal cord. The diagram shows the somatic receptors at the lower end of the neurone. The impulse must come from this receptor. Then the lower branch is dendritic in function, but in form it resembles a typical axon. Moreover, the cell body appears to give off only one branch, which is divided. Some authors say this receiving branch is an axon with dendritic function, others call it a dendrite up to the place where it seems to leave the other branch. The structure of the association neurone, Figure 1c, is suggestive of its function.

Because of their appearance the nerve tissues are classed as gray matter and white matter. The gray matter is very complicated in structure, and not well understood. Many of the neurones in the gray matter are association neurones. The white matter consists of the nerves or cables of fibers. The nerves can be seen with the naked eye and can be dissected rather easily out of any higher animal. The fibers, axons or dendrites, which make up the nerves are very small. The diameter of an axon is from $\frac{1}{100,000}$ to $\frac{1}{2000}$ of an inch. As many as 100,000 may be found together in one nerve.

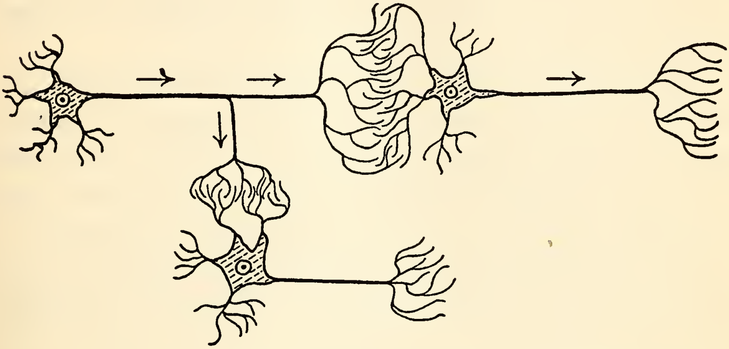

FIGURE 2. DIAGRAMMATIC REPRESENTATION OF THE SYNAPSE.
Two synapses are represented, the arrows indicating the two possible courses which the nerve impulse may follow.

**The synapse.**—A synapse is any place where the nerve impulse from one neurone may be passed on to another neurone. Typically, as shown in Figure 2, it is a place where the end brush of an axon meshes with or meets the fine branches of the dendrite of another neurone. Structurally a synapse may be a place where minute threads of protoplasm cross from one neurone to another; or, possibly the extremities of the two neurones may not be anatomically joined. This point is not settled. It is established that there is a functional junction. It appears that the synapse in some way offers resistance to the nerve impulse, thus causing a greater delay in the passage of the impulse across it than is found in the neurone itself. Furthermore, it seems very probable that this resistance varies, subject to the influence of such factors as exercise—i. e., repetition of the passage of impulses through the synapse—fatigue, presence of certain drugs, and general condition of bodily health and vigor.

**The nervous system as means of communication.**—In describing the nervous system for students of human nature, many writers have likened it to a city telephone system. It would be more accurate to say that a city telephone system is a rather inadequate man-made attempt to do for a city what the nervous system does superlatively for the human body. In a city the telephone system is obviously an inadequate means of communication. To find an appropriate analogy for the nervous system, one must add to the telephone system, the system of fire alarms, police signals, burglar alarms, telegraph, radio, U. S. mail, messenger service, bells, whistles, sirens, and other means of communication.

Reversing the comparison, we find the outposts of the nervous system to be the receptors comprising more millions of units than any city has inhabitants. Each receptor is capable of initiating a message. Thus the human body has a host of units, each capable of calling up central, sending in a fire, burglar, or other alarm. In a word, the human body has a greater news gathering organization than has the largest city or state.

The receptors are connected to the central nervous system by the sensory neurones. From the extremities of the body these neurones gather in larger and larger cables or trunk lines, then finally enter the spinal cord, the great nerve cable of the body, and find their way to the brain. Here, again, are more lines of communication than could be found in any city telephone system.

These, however, are not all of the lines. Within the brain there are vast numbers of connecting or associative neurones and commissural neurones, which make it possible for a message either to be relayed to any outgoing line or to be broadcast throughout the whole system. The system of sensory neurones and central associative neurones is completed by another great network of motor, efferent, or outgoing neurones, which carry the nerve impulses to the muscle and gland cells of the body.

This brief comparison of the human nervous system and a city system of communication does great injustice to the nervous system, but suggests its enormous complexity.

## I. The Receptors

**The sensory equipment of human beings.**—A significant characteristic of man's receptors is their specialization of function. When we speak of the senses of seeing, hearing, tasting, and smelling, we are giving expression to the fact that certain receptors are specialized so that they are sensitive to a certain kind of stimuli. Thus, the rods and cones in the retina of the eye are sensitive to light; the hair cells of the inner ear are sensitive to the effects of sound waves; the olfactory cells in the nose are sensitive to certain gases; the taste-buds in the tongue are sensitive to certain chemical solutions—sweet, sour, salty, and bitter. These four types of receptors do not include all that have a specialized function. In fact, there are several other specialized groups. The more important ones may be designated as pain, warmth, cold, pressure, equilibrium, movement, tickle, vibration, vertigo, fatigue, and sexual.[1]

There are probably over eight million receptors in the human body. On the surface of the body, in the skin, there is an enormous army of sentinels. Some thirty thousand report sensations of warmth, five hundred thousand report cold, an equal number pressure, while from two million to four million report pain. These numbers are given as the aggregate of the warm, cold, pressure, and pain spots. Each spot, in some cases at least, has more than one nerve ending. The eyes are loosely spoken of as two sense organs. In reality each eye is a complex instrument, with many accessory parts, and with some four hundred thousand rods and cones in the retina. These rods and cones are the true sense organs, but it is far more convenient in discussions of human behavior to speak of the eye as the sense organ or unit. Similarly we speak of the experiences in which the eyes are the receptors as visual experiences. The eye, including the whole eyeball with its muscles, is equipped to sense pain, cold, warmth, touch, pressure, kinæsthesia, and possibly some others; but of these sensations only those which are the normal responses of the retina to light stimuli are ordinarily called visual.

**The eye.**—The organ of vision includes (1) the protective parts, (2) the refracting parts, and (3) the retina. (See Figure 3.) Of these parts the retina alone contains receptors sensitive to light stimuli. The specialized nerve endings in the retina are described as rods and cones which are so situated that they point away from the center of the eyeball. At their outer ends there is a layer of pigment cells. Just how the rods, cones, and pigment cells function in response to light is not known.

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[1] Dunlap, Knight.—*The Elements of Scientific Psychology.* St. Louis: C. V. Mosby Company, 1922, p. 42.

Perfect vision requires that the focusing mechanism of the eye be adjusted so that a clear-cut image is thrown on each retina. Three adjustments of the eye mechanism are required. First, the iris, which controls the size of the pupil, must admit just the right amount of light. Second, the muscles attached to the eyeballs point the two eyes so that they are turned slightly toward each other when looking at an object. When the object is near, the eyes are turned in more than for distant objects. This adjustment is called convergence. The third adjustment is that of accommodation. This is the process of altering the shape of the lens so that it will throw a clear image on the retina. In a camera the lens is moved so the image

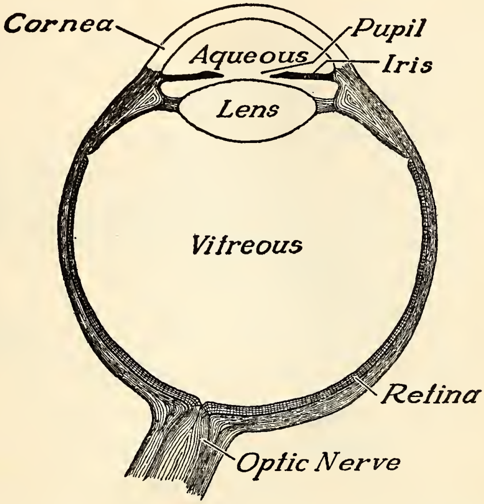

FIGURE 3. DIAGRAM OF HORIZONTAL CROSS-SECTION OF RIGHT EYE.

on the film or plate will be clear. In the eye the retina cannot be moved, hence the necessity of altering the focal distance of the lens.

An iris which is sluggish in its action is symptomatic of some nervous disturbance or abnormality. Eyes which do not converge properly are responsible for double vision and squint or "crosseye." A lens which is not true in form or which tends to be too thick or too thin is responsible for numerous abnormalities of vision. An abnormal retina results in visual defects such as partial blindness, color blindness, or night blindness.

The normal eye reports two kinds of sense data—colors and grays. Titchener says there are about thirty-five thousand color sensations which a normal eye can discriminate. Cole[1] says the workman who laid the mosaic for the Vatican must have discriminated thirty thousand different colors. There are between six hundred and seven hundred and fifty discriminable shades between the brightness of the sun's disc and the blackest obtainable black. In addition the eye is readily adaptable to different intensities of illumination. Altogether, it is by far the most generous of the receptors in the service it renders the organism.

**The ear.**—This organ is the receptor for two distinctly different senses, namely, the sense of hearing and the static sense. The latter includes sensations both of position and of motion.[2] To understand how the ear performs this twofold function, it will be necessary to consider its structure, which is very complex.

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[1] COLE, L. W.—*Factors of Human Psychology*, Boulder: University of Colorado, Extension Division, 1926, p. 134.

[2] This statement, of course, should not be taken to mean that all sensations of position and of motion have their source in the ear. As will be shown later, far the greatest number of them originate in muscles, tendons, and joints.

*General structure of the ear.*—The ear is divided into three parts—the outer ear, the middle ear, and the inner ear. (See Figure 4.) The outer ear consists of the pinna, which alone in popular parlance is called the ear, and the external meatus, A, a tube which conducts the air vibrations to the tympanic membrane, B. The middle ear is an irregularly shaped cavity in the temporal bone, from which the Eustachian tube leads to the pharynx, D. The Eustachian tube opens during the act of swallowing, thus making possible the admission of air into the middle ear to maintain equalization of pressure on both sides of the tympanic membrane.

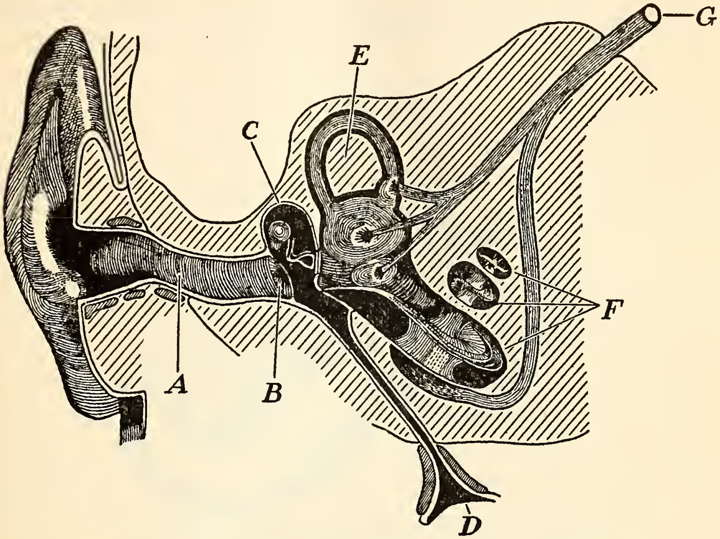

Figure 4. Vertical Cross-Section of Right Ear.

A, auditory canal; B, tympanic membrane; C, middle ear; D, Eustachian tube; E, semicircular canals; F, cochlea; G, auditory nerve. (After Hough and Sedgwick's *The Human Mechanism*, by permission of Ginn and Company, Publishers.)

The middle ear is separated from the inner ear by a bony partition, in which there are two apertures covered with a membrane and called, from their shape, the oval window and the round window. A chain of three small bones—named, from their resemblance to these objects, the hammer (malleus), the anvil (incus), and the stirrup (stapes)—stretches across the middle ear from the tympanic membrane to the oval window. By means of this series of bones, vibrations of the tympanic membrane are transmitted with considerable intensification to the outer wall of the inner ear, in which the true organ of hearing lies.

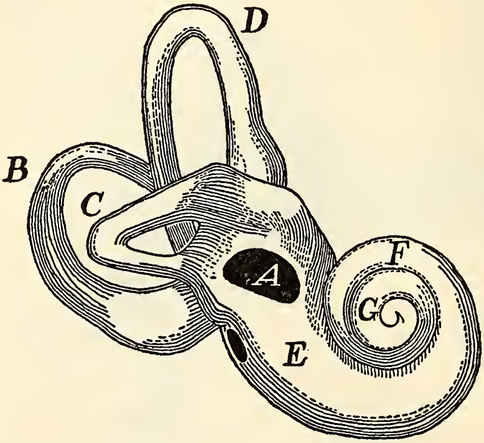

Figure 5. Bony Labyrinth (Diagrammatic).

A, oval window; B, C, D, semicircular canals; E, vestibule; F, G, spirals of cochlea. (After Hough and Sedgwick's *The Human Mechanism*, by permission of Ginn and Company, Publishers.)

The inner ear, also known as the bony labyrinth, is a very irregularly shaped cavity occupied by the similarly shaped, but smaller, membranous labyrinth, which is filled with a liquid called the endolymph. One end of the membranous labyrinth is coiled like a snail shell and for this reason is named the cochlea. The other end of the labyrinth is fashioned into three small loops about one inch in length and one-twentieth of an inch in diameter. These loops are called the semicircular canals, though each forms about two-thirds of a circle. Each of these canals lies in a plane approximately perpendicular to the planes of the other two. (See Figure 5.) All open by minute orifices into the middle portion of the membranous labyrinth, called the vestibule. The receptors for the static sense are located in the semicircular canals and the vestibule, and those for the sense of hearing in the cochlea.

*Structure of the cochlea.*—In order to understand how air vibrations give rise to nerve impulses in the auditory nerve, we must consider the structure of the cochlea. This spiral is divided throughout its windings into three tubes filled with endolymph. (See Figure 6.) One of these tubes, the scala vestibuli, leads from the oval window and unites at the apex of the cochlea with another of the tubes, called the scala tympani, which leads back to the round window. This arrangement makes it possible for vibrations of the oval window to be transmitted throughout the windings of the cochlea.

Between the scala vestibuli and the scala tympani lies the smallest of the three tubes, the cochlear duct. Part of the partition between the cochlear duct and the scala tympani is known as the basilar membrane. This membrane consists in part of some 24,000 transverse fibers, which increase in length from the base to the apex of the cochlear duct. Resting upon this membrane is the organ of Corti, in which originate the nerve impulses that result in hearing.

Some of the details of the structure of the organ of Corti, as well as its functioning, are matters of dispute. Two important types of cells are found in this organ. One type consists of rod-like cells, known as the rods of Corti. There are several thousand of these cells, each of which rests upon one or two strings, or fibers, of the basilar membrane. The other type comprises the so-called hair cells, which send hair-like projections toward the cochlear duct. The organ of Corti, however, is enclosed by the tectorial membrane, which prevents the endolymph of the cochlear duct from coming into contact with the hair cells.

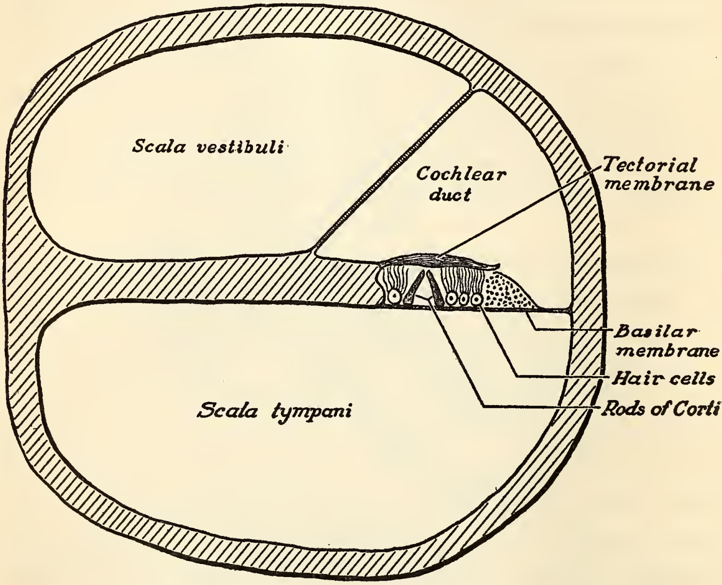

Figure 6. Diagrammatic Cross-Section of Cochlea.

*Transformation of air vibrations into nerve impulses.*— Since the hair cells are in synaptic connection with the fibers of the auditory nerve, it appears that the nerve impulses that result in the sensation of hearing must be due to excitation of these cells. There is a lack of agreement among authorities, however, as to the manner in which these excitations are produced. The trained ear is able to distinguish some 11,000 differences of pitch, in addition to discriminating and analyzing many different complex sounds. So far there has been offered no explanation of the functioning of the organ of Corti that satisfactorily accounts for this marvelous range of auditory qualities.[1]

*The static sense.*—We have already said that the static sense includes sensations of motion and of position, and that the receptors for this sense are located in the semicircular canals and parts of the vestibule. Near the vestibule the semicircular canals are dilated to nearly twice their average diameter, forming the so-called ampullæ. (See Figure 5.) In the ampullæ, and likewise in parts of the vestibule, are found cells provided with tufts of fine hairs buried in a gelatinous mass. These cells are embraced by ramifications of fibers of a branch of the auditory nerve. Since the three canals in each ear lie in planes each of which is perpendicular to the other two, any movement of the head causes a back flow of endolymph in at least one of the canals. This change of pressure against the hairs in the ampullæ excites the cell and this excitation is transformed in the auditory nerve into a nerve impulse that results in a sensation of motion.

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[1] Among the various theories as to the manner in which excitations are aroused in the hair cells, the following may be mentioned: (1) The transverse fibers of the basilar membrane vibrate sympathetically, each fiber responding to a stimulus of a definite wave length. This vibration excites only the neighboring hair cells. (2) The rods of Corti, rather than the fibers of the basilar membrane, serve as the resonators, and in turn excite the hair cells. (3) The basilar membrane, rather than separate fibers of it, is thrown into a different vibration pattern for each different wave length of stimulus, thus exciting the hair cells differently in each case. (4) The ends of the hairs from the hair cells terminate in the tectorial membrane, and the hair cells are excited by vibration patterns in this membrane rather than in the basilar membrane. None of the foregoing explanations is free from serious objections. It seems certain that the hair cells of the cochlea are the receptors for hearing, but the exact manner of their functioning remains a problem for further investigation.

The hair cells of the vestibule are excited in a different manner. The gelatinous mass in which they are embedded is weighted with minute carbonaceous particles known as the earstones. Any change in the position of the head causes a change in the manner in which the gelatinous mass pulls on the hairs. This change excites the cells and thus leads to the sensation of position.

It is worth noting that the cochlear branch of the auditory nerve, which carries impulses that produce hearing, has close connections with the cerebral cortex as well as reflex connection in the medulla and midbrain; whereas the vestibular branch, which functions in sensations of motion and position, terminates in the reflex centers of the medulla and cerebellum with no important cerebral connections. Impulses in the latter branch of the nerve ordinarily lead to reflex rather than to conscious reactions. This does not mean, however, that they are of minor importance. It has been found that, if an animal's vestibular apparatus is removed, the ability to maintain equilibrium and to perform coördinated movements is lost.

**The olfactory receptors.**—The receptors for smell are spindle-shaped cells located in the mucous lining of the nostrils, deep within, and near the top of, the nasal cavity. These cells are stimulated by fine particles of odorous substances drawn into the nasal passages in breathing and dissolved in the mucous secretion from neighboring glands. The excitation consists of chemical activity within the olfactory cells. This sense is relatively unimportant in its effects upon human mental life.

**The gustatory receptors.**—The end-organs of taste are bulb-shaped cells, located for the most part in the papillæ of the mucous lining of the tongue, though some are found in other parts of the oral cavity. There appear to be four kinds of taste-buds corresponding to the four primary taste qualities, namely, sweet, sour, salty, and bitter. The receptors for sweet taste are especially numerous at the tip of the tongue, those for bitter taste at the base of the tongue, and those for salty and sour tastes along the sides of the tongue. They can be excited only by stimuli in a liquid form. Fibers from three cranial nerves carry the impulses to the taste center in the brain.

**The organs of kinæsthesia.**—The organs for this sense are located in the joints, muscles, and tendons. Those in the joints are of most importance as they are the organs which make it possible to sense the position that is just right for the accurate delivery of a baseball, the precise stroke of the tennis racket, the correct form in writing, typewriting, playing a piano, etc. Undoubtedly a great deal of the learning of students is based upon the establishment of the correct responses to kinæsthetic cues. These cues are essential to the acquisition of correct postures in sitting and standing. The student learns to experience satisfaction when he has the kinæsthetic report which means correct posture. He is ill-at-ease or emotionally disturbed when the muscle, tendon, or joint senses report incorrect posture. The feeling of right adjustment in dancing, athletics, speaking, singing, typewriting, and manual activities is the cue for the equilibrium of the emotions. The feeling of wrong adjustment comes to mean dissatisfaction, together with the urge to seek the complacent state of mind.

**Other receptors.**—Another set of receptors which have not received full consideration by educators are those which report toxic conditions of the striped muscles. These toxic conditions are due to the products of muscular activity, the chief of these being lactic acid and probably acid calcium phosphate and carbon dioxide. Although the effect of these chemicals upon the muscles is not understood, this group of receptors report sensations which we call fatigue sensations, or feelings of fatigue. Like pain, this sense of muscular fatigue is a danger signal and not a disaster.[1]

What is commonly referred to as mental fatigue is usually due largely to the sensations of fatigue from eye muscles, muscles involved in speech, or the muscles used in holding the bodily posture assumed during study. Most of the tired feelings of students who are in good physical condition probably emanate from these sources. This should not cause the teacher to withhold proper consideration from the occasional student whose whole organism is near exhaustion because of systemic conditions.

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[1] Fatigue should not be confused with the true exhaustion of any part of the organism. If a muscle is used in rapid succession without rest, the amplitude of the movement of this part will decrease, and after some time further contraction and extension will become impossible. Before this occurs, however, a "second wind" and subsequent periods of renewed force of contraction are experienced. These are probably due to the neutralizing effects of epinephrin or adrenin on the toxins. These secretions occur under conditions of zeal, fear, and anger, and afford the basis of the efficiency of these strong motivations in resisting fatigue. When exhaustion occurs it seems to be due to a condition in the central nervous system or in some of the places where neurone meets neurone.

## II. The Connectors

**The general structure of the central nervous system.**—Figure 7 shows the gross divisions of the central nervous system in a schematic way. A glance at this figure reveals that the upper part, the cerebrum, includes a much more complex and more bulky mass of connecting nervous tissue than the lower part or spinal cord.

**The spinal cord.**—The spinal cord is about eighteen inches long in the average adult and forms about two per cent of the total weight of the central nervous system. It is usually described as having gray matter within and white matter on the outer portions. This is because the cell bodies and non-medullated axons and dendrites are within while the remainder of the cord is made up of white fiber tracts or nerves which are the main lines of connection between the brain and the receptors and effectors of the body.

Within the gray matter of the spinal cord are found three kinds of neurones: (1) those from which arise efferent or motor axons passing out through the ventral roots of the cord to the effectors; (2) those which send axons up to the brain, or to sensory neurones; (3) neurones which supply connections between the sensory and motor tracts of the spinal cord. When the connections are wholly within the lateral half of the cord within which they lie, neurones fulfilling the third function are called association neurones. When the connections bridge the median fissure of the cord thus connecting the two lateral halves they are called commissural neurones.

The associative and commisural neurones of the cord provide for reflexes which are entirely on the spinal level. The neurones concerned are spoken of as "lower centers,"

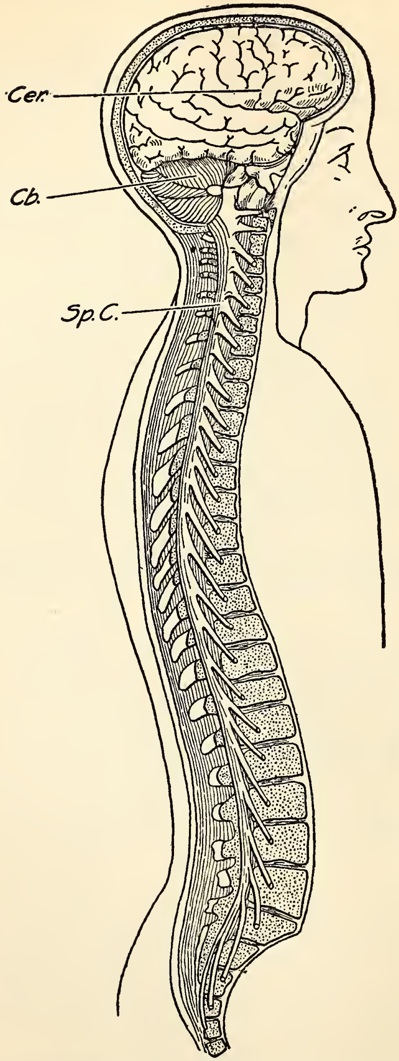

Figure 7. Longitudinal Section of the Central Nervous System. Cer., cerebrum; Cb., cerebellum; Sp. C., spinal cord. (After Angell, by permission of Henry Holt and Company.)

"lower levels of response," "spinal reflexes," etc. Reflex responses are independent of connections in the brain. This does not mean that associative and commissural neurones may not participate in more complex responses. The sensory and motor neurones which they connect have other connections and may extend onward up and down the cord.

The efferent and afferent neurones of the spinal cord are connected with the neurones of the brain. A survey of Figures 8 and 9 will show more of the nature of this arrangement than can be told conveniently in words. Figure 8 shows the general topography of the central nervous system and also the way the chief nerves of the peripheral nervous system depart from or connect with the central nervous system. Figure 9 is schematic. In this figure the gray matter of the cord is shown as a butterfly-shaped area of the cross section of the cord. The remainder of the cross section is made up of the "white matter" of nerve tracts. Notice that the motor nerves all leave the cord on the ventral side, while the sensory nerves all enter on the dorsal side after passing through or at least by the spinal ganglia.

**The cerebrum.**—The cerebrum, like the spinal cord, is composed of gray matter and white matter. The gray matter forms the outer layer or cortex and a few small masses or nuclei within the lower part of the cerebral hemispheres. Most of the interior of the cerebrum is white matter, and consists of nerve fibers with their coverings. The neurones of the cerebrum may be classified like those of the spinal cord into projection, association, and commissural neurones. The projection neurones are both motor and sensory. The association neurones connect every part of each hemisphere with every other part of that

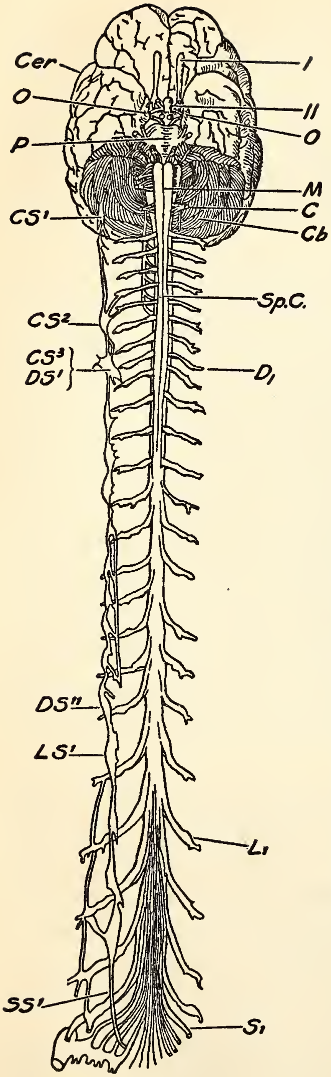

Figure 8. General View of Central Nervous System as Seen from below the Brain and in Front.

The great ganglionated cord of the sympathetic system is shown attached to one side of the spinal nerves; the other side has been cut away. Cer., cerebrum; O, olfactory centers; P, Pons Varolii; Cb., cerebellum; M, medulla; I, olfactory nerve; II, optic nerve; Sp. C., spinal cord; C, the first cervical spinal nerve; $D_1$, the first dorsal, or thoracic, nerve; $L_1$, the first lumbar nerve; $S_1$, the first sacral nerve; $CS^1$, superior cervical ganglion of the sympathetic; $CS_2$, middle cervical ganglion of the sympathetic; $CS_3$ and $DS^1$, junction of the inferior cervical and first dorsal ganglion of the sympathetic; $DS^{11}$, the eleventh dorsal of the sympathetic; $LS^1$, first lumbar ganglion; $SS^1$, first sacral ganglion. (After Angell, by permission of Henry Holt and Company.)

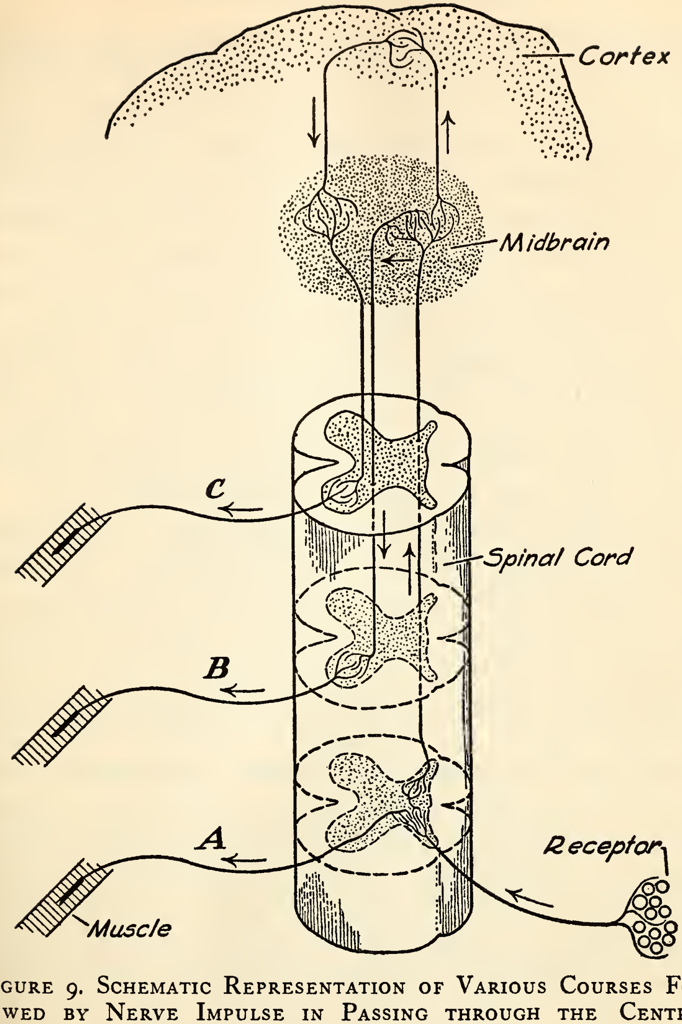

Figure 9. Schematic Representation of Various Courses Followed by Nerve Impulse in Passing through the Central Nervous System.

A, neural connection in the spinal cord; B, impulse rises to midbrain, then descends through cord, out to muscle; C, impulse rises through midbrain to cerebral cortex, then descends through midbrain and spinal cord, out to muscle.

hemisphere. The commissural neurones make connections between the parts of one hemisphere and the parts of the other. Thus the cerebrum is completely interconnected. Consequently the statement that one portion of the cerebrum "controls" or is "the center of" a certain function is liable to misinterpretation. It is inconceivable that any part could act in complete independence of the other parts. However, the functions of the cerebrum are often described as localized. This is because injury to certain portions results in the loss or disturbance of certain functions or responses. This relationship is quite constant in all men and in some anthropoid apes. Some of these regions which are responsible for the responses of the parts of the body as named are shown in Figure 10.

For convenience in describing the surface of the cerebrum it is divided into lobes and convolutions. The lobes are rather arbitrary divisions named as are the bones of the skull. The convolutions or gyri are rolls of tissue. The fissure of Rolando[1] is the boundary between two important gyri which are named the precentral and the postcentral gyri. Note in Figure 10 the words "lips, jaws, cheeks, etc." on the precentral gyrus. These indicate the motor centers for the named portions of the body. Across the fissure of Rolando dorsally are the centers for the sensations of pressure, cold, warmth, and kinæsthesis. If the superior portion of the precentral gyrus of the left hemisphere (Figure 10) were injured, the toes of the right foot would be paralyzed or unable to move but still sensitive.

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[1] The fissure of Rolando is represented in Figure 10 by the heavy line extending downward from the top of the figure. Since the figure represents the left hemisphere of the cerebrum, the centers marked "thigh," "abdomen," and so on, lie in front of the fissure of Rolando. The words "knee," "ankle," "toes" might have been placed above "thigh" in the order given, "toes" being at the top of the figure.

If the superior region of the postcentral gyrus were injured, the toes would be anæsthetic or without the ability to sense pressure, cold, warmth, and motion.

In the superior temporal convolution the auditory center is indicated. Just posterior to this center is the center for auditory speech. In the frontal lobe above and a little anterior to the centers marked "lips" and "tongue" is the center for motor speech. Injury to the center for auditory speech results in the loss of the ability to understand spoken words, as well as the loss of ability to interpret rhythm, meter, and auditory sensations in general. Injury of the region for motor speech causes the patient to forget or lose the ability to speak although in some cases the patient may still be able to sing.

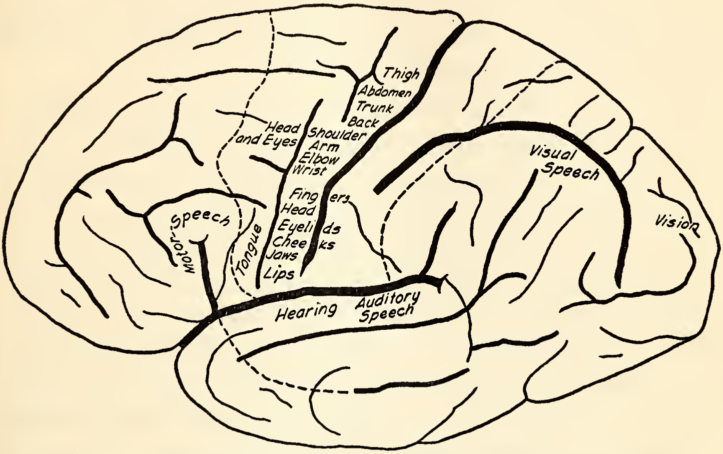

Figure 10. Localization of Function in Cerebral Cortex of Left Hemisphere.

(After Herrick, by permission of W. B. Saunders Company.)

Just as the speech centers seem to control functions which are more complex than the toe and knee centers, so in the unmarked areas of the cortex it is conceivable that there are centers for the control of the other more complex functions. At one time the phrenologists made complete maps of the cortex, locating the centers for pugnacity, parental love, memory, and many other so-called faculties. This belief has been completely discredited. More recently "moral centers" and "association centers" have been suggested. So far, no one has been able to establish satisfactorily such relationships.

Even the localization of function as implied in the preceding paragraphs and in Figure 10 is in doubt. There is considerable evidence that the function controlled by a certain center is taken over by other portions of the cortex after the center is destroyed. It is also probable that the layers of the cortex may differ in their functions. The facts seem to be that the destruction of specific regions of the cortex results in the loss of certain specific responses. Later these responses are regained although the center destroyed is not rebuilt. There are many theories which attempt to explain these facts but the true relation between the behavior of man and his nervous structure is not fully explained.

**Levels of connection.**—The spinal cord and brain stem provide connections for many of the more simple, less conscious, and most immediate responses. These connections are often designated as those of the lower levels. By contrast the cerebrum contains the connections which function in responses which are complex, conscious, and often delayed. Neurones of the spinal cord and brain stem are in direct connection with the sense organs and the muscles. The neurones of the cerebrum connect with the sense organs and muscles only by way of the brain stem and cord.

If an incoming nerve impulse is short-circuited across to an efferent neurone in the cord, the resulting response is of the reflex type. Figure 9 illustrates two levels of connections (A and B) which function in reflex acts, and also a connection of the third level (C) in the cerebral cortex which is, in general, the result of learning, and the functioning of which is attended by consciousness. The first case of reflex action is, relatively speaking, simple, prompt, certain, predictable, and frequently unmodifiable by training. The sensory neurone is connected in the spinal cord[1] with one or more motor neurones which convey the impulse to organs of response (muscles or glands). In the second case of reflex action, the impulse is conducted through the cord to the mid-brain or to the cerebellum, where the connection with the motor neurone (or neurones) is made. The resulting response is usually more complicated, more easily modified by training, and less predictable than the response at the first level. In either case, however, if consciousness of the response is present, it seems to follow rather than to precede the action.

If a nerve connection is short-circuited in the cord, it may be long circuited through the cerebrum. Let a person grasp a rose bush, perhaps thinking it some thornless shrub. The withdrawing reaction is immediate and involuntary. But if the same person be climbing a very steep mountain trail and if he should slip and be falling over a precipice he might grasp a thorny bush with a grip supervised by cerebral connections which would countermand the reflex order and long circuit the usual lower connection. The pain sensation from the thorn stimulus can say "Let go" with a good chance of obedience unless the higher cerebral connection gathers together the accumulated experience of days and years and enables it to shout the order "Hang on." The "hanging on" response may be a delayed response to experience in a remote past or it may be chiefly due to inherited connections. Certain it is that the organization of the connectors in the cerebrum enables us to plan for the distant future and then act in accordance with those plans when that future becomes the present. Much of education would be waste if this were not so.

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[1] This connection may be made with or without the aid of an intermediate neurone, and at one or more points in the cord at, above, or below the level at which the sensory neurone enters the cord.

**The autonomic nervous system.**—The autonomic[1] nervous system is composed of two trunks of ganglia extending along the spinal column and of numerous other ganglia, some of which are situated in or near the organs that they control. The two trunks of gangliated cords extend from near the second cervical vertebra to the coccyx. They are intimately connected with the spinal nerves. The neurones of the autonomic system resemble the typical neurones of the cerebro-spinal system, but they are more often lacking the medullary sheath. Embryologically they have a common origin with the cerebro-spinal system.

Of the functions of the autonomic nervous system, the following are representative: acceleration and slowing of the heart beat; regulation of distribution of blood supply by altering size of blood vessels; control of the alimentary canal, the bladder, and the reproductive organs; and control of the glands. The functions of the autonomic system have a common characteristic, that of being less easily brought under direct conscious control. The responses activated by the cerebro-spinal system are characteristically responses which we make; those activated by the autonomic system are responses which make us different beings, temporarily at least. The latter include such responses as the alteration of the size of the blood vessels in blushing; the glow of the skin after a cold shower, and a rub down; the flush of the skin when the temperature rises; the pallor of fear.

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[1] That portion of the nervous system which we shall call the autonomic system has also frequently been called the sympathetic system. In strict accuracy, it appears that a portion of it—that part between the second dorsal and the second lumbar vertebræ—should be called the sympathetic system and the remainder the autonomic. See DERCUM, F. X.—*The Biology of the Internal Secretions*. Philadelphia: W. B. Saunders Company, 1924. 241 pp. For our purposes, however, this distinction need not be made.

## III. The Effectors

**The meaning of reaction.**—A nerve impulse originating in a sensory neurone as the result of stimulation tends to produce an overt reaction in the organism. For example, if a pain neurone in a finger is stimulated by the pressure of a sharp point the resulting nerve impulse produces a movement of the hand. This movement is called the *reaction* to the stimulus. The term, however, has a broader meaning than this illustration suggests. Reactions include blushing, swallowing, coughing, contractions and expansions of the iris of the eye, contractions and expansions of the digestive organs, and many other bodily adjustments that are not readily observable. In addition to all such reactions, there are glandular reactions whose products are chemical secretions, and cortical reactions which produce states of consciousness. Thus the term reaction refers to all kinds of responses that the organism makes to stimuli—movements, glandular action, and conscious states.

**The muscles.**—The large muscles that function in walking, striking, dodging, stooping, and the like are the most apparent parts of the reacting mechanism of the human body, but in relation to the learning process they are probably the least important. The small muscles such as those that operate the vocal organs or move the eyes in reading are more important. All of these muscles are similar in structure. Each one consists of thread-like cells of muscle fibers which lie parallel to each other. Due to this structure these muscles are called *striped* or striated. The cells possess the property of contracting in response to the nerve impulses that reach them through the motor neurones.

The muscles in the walls of the stomach, in the diaphragm, in the walls of veins and arteries, and the like, have a different structure. Instead of the thread-like fibers the units of structure resemble tapering spindles. On account of their structure these muscles are called *smooth*. Their reactions are similar to those of the striped muscles, but there is a significant difference in the neurone connections with the spinal cord. In the case of the striped muscles, the connection is by means of a single motor neurone; in the case of the smooth muscles, a motor neurone emanating from the spinal cord terminates in a ganglion center and from it other neurones extend to smooth muscles and *glands*. In this way the action of glands and smooth muscles is synchronized. As contrasted with the unstriped muscles, the striped muscles seem to be under our control or, as it is frequently stated, "they are under the direct control of the will." They are the "voluntary muscles."[1]

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[1] The terms "will" and "voluntary" are used and accepted uncritically. If carefully analyzed, they present serious and interesting problems.

Before reaching the muscles, the motor axons from the cerebro-spinal system branch liberally so that each fiber of the motor neurone may send branches to from ten to one hundred muscle cells. These nerve branches terminate in so-called end-plates. These end-plates lie on the muscle cell near its middle. It appears that two nerve branches generally have end-plates on one muscle cell. In addition to these motor axons there are sensory nerves and branches of the autonomic system supplying the muscles. These latter probably control the blood supply of the muscles.

*Contraction of the muscles.*—The statement that the striped muscles are "voluntary muscles" implies that they do not act independently of conscious states but respond only when they receive the appropriate impulse from the central nervous system. When their connection with the central nervous system is severed they are paralyzed. The response to the impulse from the central nervous system is called a contraction. This means that the muscle cells shorten and thicken. Careful research has established the fact that this contraction is that of a thin elastic envelope filled with a viscous or jelly-like substance.

A simple contraction or twitch has a characteristic form. When the muscle is stimulated, it remains inactive for perhaps 0.005 of a second (the latent period) then shortens or twitches. This shortening is slow at first, then rapid, until the muscle reaches its greatest contraction, after which it relaxes slowly. The whole twitching and relaxing occupies about 0.1 of a second. It has been found that the trained pianist or typist cannot press a key with one finger more rapidly than eleven times a second. Stiles[1] says "we are far inferior to flying insects, whose wings may beat three hundred times or more" in a second. If the stimuli come rapidly, and the muscle has no chance to relax, it remains in constant contraction or tetanic contraction.[1] The rapidly recurring stimuli seem to produce a summation effect if timed just right and the resulting contraction is more vigorous than the simple twitch.

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[1] Stiles, P. G.—*Human Physiology*. Philadelphia: W. B. Saunders Company, 1916, p. 71.

If these contractions are characteristic, how do we move slowly? It is thought that each muscle fiber acts independently. Hence a slow movement of the hand occurs through the typical contractions of first a few cells, then more, and so on until the whole muscle has reached the required contraction. Contrasted with the striped muscles, the smooth muscles are more sluggish in their movements and tend to maintain a constant tonus. The location of the smooth muscles suggests that they are rarely called upon to make the sudden and precise adjustments which are a nearly constant requirement of the skeletal muscles.

*Exercise and recovery.*—There is a regular "oxygen requirement" for each individual. If his exertions advance this requirement beyond his means for supplying oxygen, there must be a rest period or complete exhaustion will follow. After exercise or exertion rapid and deep breathing occurs. This breathing is the organism's effort to repay the "oxygen debt" incurred during the rapid movement. The need for oxygen during the working period has not been met. In other words, the organism has "lived beyond its income." Hence the necessity to repay the exhausted principal of oxygen. The deficit of oxygen is expressed by an accumulation of lactic acid in the blood and muscles. The presence of this acid results in the sensations of fatigue and, if great enough, in exhaustion. The oxygen requirement is relatively greater for younger children. They cannot afford to pile up great "oxygen debts"; their exertions must be mild and of brief duration with liberal opportunities for rest. The ability to keep up vigorous exercise increases with maturity and with training.

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[1] The majority of the muscular reactions are tetanic contractions.

In rigid muscles the blood supply is practically cut off. Active muscles are never rigid for more than an instant; therefore their blood supply is better and the lymphatic circulation and disposal of wastes are much better. Hence the need for mild but frequent exercise during childhood and youth. Rigid postures are certainly unhygienic if maintained for any length of time.

**The glands and their general function.**—The glands are true effectors or response organs since they react to efferent nerve impulses. Their innervation or supply of nerve fibers is similar to that of the muscles. Some of the glands contain smooth muscle fibers. As indicated by their names, the endocrines or ductless glands have no ducts or outlets through which their secretions, called autacoids, may be discharged. They must send their secretions into the blood stream through the walls of the blood vessels. Obviously this distinction marks them off from the duct glands. The latter group includes the tear glands, the salivary glands, the pancreas, glands in the walls of the stomach, the liver, the sweat and sebaceous glands of the skin, and the kidneys. The functions of this group of glands are familiar to the student, and therefore little need be said of them here. The significance of the endocrine glands in the economy of the human organism is, however, not so commonly understood. A brief consideration of them will be helpful.

From the time of the ancient Greeks, physicians have believed and taught that disease arose from some lack of harmonious combination of the "four humors" of the body: excess of black bile producing melancholia; excess of red bile or blood producing the sanguine temperament even to high fever; excess of white bile or phlegm producing the phlegmatic temperament; and excess of the yellow bile producing the bilious temperament and "bilious attacks." Like many shrewd and plausible guesses of the past this suggests the modern view. The present theory relative to the autacoids is that excessive secretions or deficiencies are responsible for certain pathological conditions. For a century and a half the ductless glands have been making recurring bids for the focus of public attention. These bids have ranged from the promise of the cure of minor ailments to the assurance of rejuvenation and the guarantee of permanent changes in character.[1] These promises are still among the hopes of the more optimistic scientists. It is well established that the secretions of the endocrines are very potent in their effects on the organism. The complete technique of their use is not known.

**Secretions of the ductless glands.**—The secretions of the ductless glands may be thought of as being drugs which are poured into the blood stream. Like drugs they produce significant modifications in the responses of the organism. Collectively these secretions are designated *autacoids*. If an autacoid is exciting in its effect it is called a *hormone*[1] or excitant. If an autacoid has a relaxing or depressing effect it is called a *chalon*. It is a well-established fact that these autacoids influence physical growth and modify the action of the digestive, the circulatory, and the reproductive organs. Changes in emotional state and affective tone accompany some of these changes in organic action. We know that people vary in their energy or zeal. At times they work with great vigor which sometimes mounts to maniac excitement; at other times they work with great persistence. Again there are times when certain persons are depressed and are apparently or actually unable to work at all.

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[1] Théophile de Bordeau published a monograph in 1776 which anticipated some of the modern theories of the effects of the endocrine secretions. Brown-Sequard in 1889 reported "amazing stimulation of muscular power and mental activity following the hypodermic injection in man of the secretions from the testes of monkeys and dogs."

In addition to those persons who are frequently or always unhappy and those who are divinely restless, there are many people who are usually content with themselves, their cars, their friends, their communities, and all within their worlds. Although more intimate knowledge might reveal passing storms of emotions in every case, their characteristic mental attitude is that of a consciousness of well-being. These conditions of the organism are only samples of many emotional states, all of which are thought to be caused by, or at least related to, the activities of certain endocrines.

The functions of the endocrines are learned by observing the effects produced by the presence or absence of their secretions in the organism. The absence of the autacoids may be brought about deliberately by removing certain glands. It also occurs through destruction of a gland by disease, or it may be due to the inborn deficiency of a gland. Such observations may be checked by the injection of the extract of the gland concerned. Glands may also be hyperactive and thus produce an excess of their secretions. The results of such observations are summarized briefly for the following ductless glands: the thyroids, the parathyroids, and the adrenals.

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[1] Hormone is or has been frequently used as the more general term, but autacoid is better as its meaning is that of a remedy or drug. Hormone should be reserved for the restricted meaning of an excitant.

**The Thyroids.**—The two lobes of the thyroid are located one on each side of the windpipe close to the larynx. These lobes are joined by a narrow isthmus of thyroid tissue. With each lobe of the thyroid there are two parathyroid glands, one superior, often embedded in the thyroid proper, the other inferior, sometimes at a little distance from the thyroid.

Abnormal conditions of the thyroid gland are (1) enlargement with or without excessive secretion; (2) excessive secretion; (3) deficient secretion. The symptoms accompanying mere enlargement may be only the local swelling. Symptoms accompanying excessive secretion or hyperthyroidism are increased metabolism, rapid heart beat, emaciation, and nervousness. In some serious cases there is a characteristic bulging of the eyes. The symptoms of thyroid deficiency or myxedema are generally just the opposite of those which go with hyperthyroidism. Instead of increased metabolism there is a reduced metabolism. Instead of rapid heart and nervousness there is a slow pulse and apathy. Instead of thinness there is corpulence. In the place of the bulging eye or the characteristic excessively bright eyes of the hyperthyroid, there is the dull eye of myxedema. The connective tissue beneath the skin grows excessively, causing the disappearance of the normal contours of the body and giving an appearance of coarseness, uncouthness, and heaviness to body and features. This condition merges into the animalism of certain types of idiocy.

From these symptoms it may be concluded that the thyroid secretion is a governor of metabolism. The active principle of the thyroid secretion was found and isolated by Kendall after nearly nine years of research. He called it thyroxin. Kendall asserts that he has never found a case of thyroid deficiency which did not respond favorably to an intra-venous injection of thyroxin. Along with an increased rate of metabolism, the injection of thyroxin changes the other symptoms described under myxedema.

**The Parathyroids.**—When the parathyroids are removed the animal usually dies in a few days. After the first day or two the symptoms are paroxysms and convulsive fits. These symptoms together with other evidence lead to the assumption that the secretions of the parathyroid act as governors of the nerve cells, preventing them from becoming too active.

**The Adrenals.**—The adrenals or suprarenals are attached to the kidneys and lie just under the diaphragm. An extract of the adrenals is sold under the name of adrenalin. The effects of the secretions of the adrenals are quite complex. They may be roughly classified as (1) general continuous systemic effects and (2) emergency effects.

The general systemic effects are not fully known. In animals removal of the adrenals always produces death even though the extract is administered. Death does not follow immediately after removal but after a few days the animal shows signs of muscular weakness and lack of coordination. Then follows low blood pressure, feeble pulse, general weakness, and finally death. Administration of adrenalin to normal animals appears to have a direct effect on the autonomic nerves which supply the smooth muscles. The secretions of bile and of saliva are increased. The spleen is contracted and there are pronounced effects on the sex organs.

In describing the emergency effects of adrenalin we must anticipate a discussion of the emotions.[1] Certain emotional states of the organism have common characteristics. Fear, anger, and zeal are easily recognized as being states of readiness for emergencies. During fear the organism is set for flight or defense. In anger the muscles are ready for the attack. When zeal is the controlling state of mind the organism is full of the drive for extreme exertion. In those crucial situations the resources of the organism must be mobilized. Adrenalin assists in the mobilization.

Changes in the distribution of the blood are involved in this mobilization. The digestive system and the whole abdominal and pelvic regions are denied the blood supply needed for their normal activities, while the motor apparatus is given an increased quota. Not only is there an increased blood supply for the muscles but the blood is enriched by the addition of the glycogen which the liver is stimulated to produce, owing to the presence of the adrenalin in the blood. This glycogen is clearly an emergency ration. Adrenalin in the blood causes it to clot more quickly than ordinarily, thus increasing the probability of survival of the wounded through reduction in loss of blood. This property has caused the use of adrenalin in local anæsthetics such as novocaine when employed in operations in the mouth, nose, throat, etc. Along with all these changes the muscles are in some way freed from the effects of fatigue, if fatigued, or rendered more immune from fatigue toxins while they are active. This probably accounts for the phenomenal feats of strength performed by persons during great excitement. The facts are that

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[1] See pages 97f.

"fear lends wings," that desperation gives strength to the cornered animal, that the researcher in sight of his goal has a tireless energy, and that although we may seem tired or even exhausted an exciting event will set us going again in forgetfulness of the fatigue of the moment just past.

**Other endocrine glands.**—The endocrine glands just described have a monopoly of interest for the psychologists. The other endocrines are not known to be so important in their direct effect on behavior. The sex glands have an endocrine function in addition to their primary function of reproduction. This is evidenced by the presence of secondary sexual characteristics, the beardless face of the woman, the beard of the man, the feminine voice and form as contrasted with the typically masculine, and other so-called sex differences. There has been a perennial search for precise statements of the mental and temperamental differences between the sexes. That "men must work and women must weep" may be due to the endocrine functions of the glands of sex but there is no precise statement of the sex differences in working and weeping. At present, interest in individual differences tends to obscure the attention to sex differences.

The pituitary, the pineal, and the thymus glands produce effects on growth which are of interest to the student of child development. An overactive pituitary in children produces giantism; in adults it produces acromegaly or enlargement of the bones of the face and the extremities. The thymus and pineal glands are thought to exert some effects on the growth of children. A normal pineal gland probably inhibits growth and development, since a disturbance of the pineal results in precocious growth. The thymus is large in embryonic life and during infancy but at about the time of puberty it gradually diminishes in size. It may have functions throughout life but its growth indicates that its more important functions must occur in the period of rapid growth before adolescence.

**The maturing of the human mechanism.**—As compared with the young of most forms of animal life, the human infant is extremely helpless and dependent upon others. Many animals can, almost from the hour of birth, perform nearly all the movements, or make practically all the adjustments with their environment, that they will ever be capable of. Even in the case of an animal that is comparatively helpless at birth, the period of development to maturity is a relatively short one. Most of the responses required of the animal are relatively simple and are provided for by inborn neural connections that are ready to function early in life. The child, however, requires many years for his development, and does not arrive at maturity until almost a third of his threescore years and ten have passed.

The child's development, both physical and mental, is most rapid during the earliest years of life. From the time of his entrance into school until well into the high-school age, however, his development is fairly constant and regular.[1] There are, it is true, some fluctuations in the rate of development, as well as individual and sex differences in this respect, but the maturing process in general may be best described as gradual.

A few specific facts in connection with bodily growth and development are worthy of mention. As compared with the other organs of the body, the brain is relatively very large at birth, having then about one-fourth of its final weight. Its weight increases about two and one-half times during the first year of life, and by the middle of the fifth year has reached about ninety per cent. of the final weight. After the fifth year increase is slow until the maximum weight is attained, which occurs at about the age of fifteen. The sense organs develop rapidly and at the age of three are almost as sensitive as they will ever be. Most of the glands function from birth till death, though the pineal and the thymus cease to function at adolescence. The first permanent teeth appear at six years of age and the last, with the exception of the third molars or "wisdom" teeth, at about fourteen. Since each permanent tooth has a normal time at which to make its appearance, an approximate measure of the child's physiological or anatomical age may be obtained by an inspection of his teeth. This physiological age may vary considerably from his chronological age.

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[1] For a statement of the opposite view and the arguments in support of each view, see Inglis, Alexander.—*Principles of Secondary Education.* Boston: Houghton Mifflin Company, 1918, Chapters I and II. The general topic of development will be considered in Chapter XI.

One other important aspect of physical development due to growth and the maturing process should not be overlooked. The nervous system possesses at birth some degree of organization and of readiness to function in the production of many responses, particularly those upon which the maintenance of life depends. Among the activities for which provision is made at birth by inborn neural connections may be mentioned breathing, digestion, circulation of the blood, crying, diffuse bodily movements, and a number of the simpler reflexes. But it seems that other neural connections, or patterns of neural organization, appear later as the result of maturing and independently of training. Thus it appears that the neural organization, necessary for the coördinated movements of walking, is not present usually until the age of twelve or fourteen months and that, when the process of growth has brought about this neural organization, the child walks without the necessity of any learning period. In a similar fashion, many innate tendencies toward behavior make their appearance as growth and development continue, among the latest of which are the sex instincts, which come to be very powerful at the time of adolescence. The appearance of all these so-called "delayed instincts" is due to the development of synaptic connections resulting from the process of growth.

**Concluding statement.**—In this chapter the reader's attention has been called to certain features of the human mechanism in order to assist him in understanding the topics discussed in the following chapters. The sense organs, the nervous system, and the muscles and the glands form a highly complex physical mechanism. It is sensitive to a great variety of stimuli to which it responds in characteristic ways. Its responses, however, are governed by controls, some native or inherited and others acquired. Furthermore, it possesses the property of being modified by its own activity. The nature of human responses to stimuli, the types of controls of conduct, and the nature of the learning process are the central topics of the three following chapters.

## LEARNING EXERCISES FOR THE READER

√1. Of the three classes of neurones (sensory, association, and motor), which, in general, should you expect to be the shortest? Why?

2. What are the traditional "five senses"? Does this list include all the sensations we experience? Add to the list as many others as you can.

✓3. Draw a diagram showing the course of the nerve impulse aroused when the hand touches a hot stove. Is consciousness involved in this case? Explain. Make provision for it in your diagram.

✓4. Explain, with the aid of a diagram in each case, the chief aspects of the neural activity involved in each of the following experiences. (Consider the most probable response in each case.)

a. A boy sees a coin lying on the sidewalk.
b. A's friend calls to him from the other side of the street.
c. A child bites into an unfamiliar substance, which proves to be distasteful.

✓5. Why does one sometimes "see stars" when struck on the head?

✓6. In what respects is the eye like a photographic camera? In what respects different?

✓7. What is the cause of nearsightedness (myopia)? Of farsightedness (hypermetropia)? What kind of glasses in each case will remedy the defect?

8. Are sensations of warmth and of cold felt at all points on the skin? Are warmth and cold felt at the same spot? Are the warm spots or the cold spots more numerous? You will probably be able to determine for yourself the answers to these questions in the following way: Take any metal object of convenient size and having a small, though blunt, point. An Eversharp pencil with lead removed will answer the purpose. Cool it by placing it in cold water for a few minutes. Then holding the pencil perpendicular to the skin, move the point of the pencil over the back of the hand or the forearm. Locate a number of cold spots and mark a few of them with dots. Again, place the pencil in hot water for a few minutes, or heat it in a flame until it is quite warm, though not unpleasantly hot. Then proceed as in searching for cold spots. It may prove to be somewhat more difficult to discover the warm spots, but you should succeed after a few trials. Also apply the warm pencil to the cold spots you had marked and note whether a sensation of cold follows.

9. Take a fine-pointed needle and press gently, but with uniform pressure, upon the skin of the wrist in a number of places.

Is the result the same everywhere? Which appear to be more numerous, pain spots or cold spots?

✓10. Suppose the optic nerve and the auditory nerve were severed near the brain and each nerve then joined to the stump of the other. Could the individual then hear the lightning and see the thunder?

Read: Ladd and Woodworth.—*Physiological Psychology.* (Consult Index for "Specific Energies of Nerves.") Warren. —*Human Psychology.* (References in Index under "Mode of Nerve Impulse.") ✓Robinson and Robinson.—*Readings in General Psychology*, pp. 44–45. Mitchell.—*General Physiology*, pp. 411–12.

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✓11. Practice until you can draw from memory satisfactory diagrams of: the eye; the ear; the areas of localization of the cortex; a cross-section of the spinal cord, with its sensory and motor connections.

✓12. In the light of the theory of neurones and synapses, suggest a possible explanation of sleep.

13. Read: Hough, Theodore, and Sedgwick, William T. —*The Human Mechanism.* Boston: Ginn and Company, 1918, pp. 269–74, and compare the behavior of a frog with various portions of its nervous system removed with the behavior of a normal frog.

✓14. How does the brain of a feeble-minded person differ from the brain of a normal person? Read: Woodrow, Herbert.—*Brightness and Dullness in Children.* Philadelphia: J. B. Lippincott Company, 1919, Chapter IV.

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✓15. Prepare a list of the technical terms you have learned in studying this chapter. Can you define each of them? If not look up the definition.

J.B.P.

# CHAPTER III

## HUMAN RESPONSES TO STIMULI

**The problem of this chapter.**—The general problem of this chapter is to describe the various types of responses that human beings make to stimuli. This is a very comprehensive topic and the following discussion is necessarily limited to those aspects which seem to be most important as prerequisites for understanding the learning process.[1]

**Meaning of "stimulus" and "response."**—The preceding chapter presented a view of the nervous system as an inconceivably complex intermediary between two sets of end-organs, the receptors and the effectors. The function of the receptors was seen to be the origination of nerve impulses which, when transmitted by the nervous system to the effectors, produce muscular contraction and glandular secretion.

So far as we know, no nerve impulse ever originates in the nervous system except as the result of some force or condition external to the nervous system. Thus, certain ether vibrations produce excitations in the retinal rods and cones; certain air vibrations excite the hair cells of the inner ear; objects in contact with the skin arouse the tactual end-organs to activity; and so on through the entire list of receptors, each of which is aroused to activity by some form of energy to which it is peculiarly sensitive. Any force or condition external to the nervous system which produces an excitation in some receptor is called a *stimulus*. A complex of stimuli is called a *situation*.

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[1] The reader who is interested in a more extended discussion should consult one of the following:

Dunlap, Knight.—*The Elements of Scientific Psychology.* St. Louis: C. V. Mosby Company, 1922. 368 pp.

Warren, H. C.—*Elements of Human Psychology.* Boston: Houghton Mifflin Company, 1922. 416 pp.

Woodworth, R. S.—*Psychology.* New York: Henry Holt and Company, 1921. 580 pp.

It is important to note that, although all stimuli are external to the nervous system, not all are outside the body. It will be remembered that the muscles, tendons, and joints contain receptors that are stimulated by conditions of bodily motion, strain, fatigue, and the like. The semicircular canals of the inner ear and the receptors that report conditions of the vital organs are other examples of receptors that are sensitive to stimuli within the organism.[1]

When a receptor is aroused to activity by a stimulus, a nerve impulse is produced in a sensory neurone leading toward the central nervous system. This impulse normally issues in muscular or glandular activity, or both. It may be transferred to a motor neurone in the spinal cord or mid-brain, thus issuing in a reflex action in which consciousness is not involved, or it may be conducted to the cerebral cortex and give rise to a state of consciousness before passing over motor neurones to muscles or glands. This total reaction to a stimulus, beginning in the receptor and terminating usually in muscles and glands, is called a *response*.[2]

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[1] The stimuli outside the organism are called *peripheral* to distinguish them from those within. The latter group include two classes, *kinæsthetic* and *visceral*.

[2] The term "response" is often applied only to that portion of the total reaction to a stimulus which takes place in muscles and glands. When the term

**Range and variety of human responses.**—The most striking and the most significant fact about the human organism—especially that portion of the total organism with which educational psychology is primarily concerned, the nervous system and its terminal organs—is its indescribable complexity. It is a far cry from, let us say, the simple, diffuse nervous mechanism of the sea-anemone, in which the receptors and effectors are linked together without any central nervous system, to the human brain and spinal cord with their fifteen billions of neurones. But the difference in structure between these two forms of life is not greater than the difference in their behavior. An inventory of all the responses which the sea-anemone is able to make would appear strikingly meager in contrast with a complete catalogue of the items of the behavior of a normal human being.

In order to gain some conception of the vast range of responses of which the human organism is capable, one may begin by listing such activities as walking, talking, reading, writing, eating, swimming, remembering, thinking, playing golf, driving an automobile, singing, dressing, playing bridge, typing, skating, seeing, hearing, fearing, and fighting. This list, of course, is only a very brief one, and could be prolonged indefinitely; but even so, it does not give the reader an adequate idea of the number of responses it is possible for a person to make. One must analyze each such activity as those listed above into the more elementary responses involved in it.

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is used in this sense, one is forced to choose between (1) wholly disregarding the portion of the total reaction which occurs between receptor and effector and (2) assigning some other name to this part of the reaction. The present writers believe that no portion of the total reaction should be disregarded and also that there is no necessity for employing two or more terms to designate this reaction.

To illustrate such an analysis,[1] let us consider "talking." The speaking of a word is a response; the activity of "talking" includes a response for each word in a person's speaking vocabulary. Doran[2] found a boy of nine who knew 6,031 words; one of thirteen who knew 26,300 words; a senior high-school boy who knew 41,000 words. His own vocabulary he estimated at 100,000 words.

The writing of a word is another type of response and a person's writing vocabulary must be added to his speaking vocabulary in the enumeration of his potential language responses. The writing of a word is not an elementary response. Writing a word on a typewriter includes a very different set of responses from those that occur in writing it in longhand or in shorthand. Furthermore, writing the letter "o" between "w" and "r" as in "word" requires a different adjustment from writing the letter "o" between "n" and "t" in the word "another."

From the foregoing illustration it is clear that, if all the separate responses that an individual can make were identified and listed, the result would be an almost endless list. In order to deal with them conveniently, therefore, it will be necessary to effect some sort of classification. Before attempting a classification, however, some consideration must be given to certain matters relating to a very significant element of most responses, commonly called *mental activity*, or *conscious processes.*

**Mental activity.**—Everyone knows, at least in some measure, the difference between being conscious and being unconscious. Consciousness is simply awareness of some-

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[1] In this illustration there is no reference to mental activity. Note the discussion of this phase of response on pages 73f.

[2] DORAN, E. W.—"A Study of Vocabularies," *Pedagogical Seminary*, 14:401–38, December, 1907.

thing. One may be aware of something—some object, quality, relation, movement, or event—now present; or of something which has been present, but now is not; or of something which is expected to be present; and so on. Each such case of awareness is called a *mental act*, or a *conscious state*, or a *conscious process*. Within each person there is a continuous stream or succession of conscious processes unless the flow is interrupted by sleep or by an abnormal condition such as serious illness, a blow on the head, the presence of certain drugs in the system, fainting. We shall use the term *mental activity* to mean this stream of conscious processes, or any segment or portion of it.

In addition to the ever-changing, fluid nature of mental activity, a second important characteristic is implied in the above description of the enormous range and variety of human responses. Since most of these responses are accompanied by consciousness, it follows that mental activity must also be extremely varied and complex.[1] A third significant attribute is its peculiarly subjective character. Mental processes are unique among the phenomena of nature in that they can be known directly only by the person who experiences them. No one but myself can know directly my mental state when, for example, my home team scores a touchdown in the game I am witnessing. I may describe it to my neighbor, or he may infer it from my behavior or from similar experiences of his own, but he can know it only indirectly. Hence conscious processes can be studied only by the method of *self-observation*, or *introspection*.

**The neural basis of mental activity.**—The ultimate nature of mind has long been a center of philosophical controversies.[1] While the facts of psychology remain the same whatever the relation between mind and body may be, the psychologist can hardly avoid speculating upon this relationship. At present there is a lack of agreement among psychologists with respect to the question. To illustrate this divergence of beliefs, we shall state briefly two of the various views that are entertained at the present time.

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[1] This feature of mental life will demand our attention at considerable length later in this chapter. See pages 76f.

According to one view, the mind is a non-material entity, a structural unity, with a history and development dependent upon, yet not strictly parallel with, the growth and development of the central nervous system. It possesses continuity and permanency throughout the life of the organism. It stands in the relation of cause and effect with the brain and, through the brain, with the rest of the body; that is, it is influenced by bodily states and in turn exercises an influence upon bodily conditions and movements. Thus we read:[2] "Finally, then, *the assumption that the mind is a real being, which can be acted upon by the brain, and which can act on the body through the brain, is the only one compatible with all the facts of experience.*"[3]

In contrast with the view just presented is the belief that mind as a real being, or entity, does not exist. Conscious processes are simply manifestations of nerve impulses in the neurones of the cerebral cortex.[4] Thus the flow of nerve impulses in the neurones of my cerebral cortex appears to me, or is known to me, as states of consciousness; whereas, if an outsider could view this same neural activity, he could observe only electrical and chemical change. Consciousness and nerve impulses are but two aspects of the same thing.[1] Hence, mind at any moment is only one aspect of the cortical activity going on at that moment and ceases to exist at the cessation of this activity. Mental activity is nevertheless worthy of study since, being one aspect of the neural activity that determines behavior, it throws much light upon neural processes which are not otherwise observable.

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[1] For an extended discussion of this question see Bode, B. H.—*Conflicting Psychologies of Learning.* Boston: D. C. Heath and Company, 1929. 305 pp. This writer takes the position that the theory of mind accepted is important.

[2] Ladd, G. T., and Woodworth, R. S.—*Elements of Physiological Psychology.* New York: Charles Scribner's Sons, 1911. p. 654.

[3] This is known as the interaction hypothesis.

[4] It has been suggested that the relation between conscious processes and nerve impulses is similar to that existing between the light given off by the filaments of an electric light and the electric current passing through them.

The two views set forth above do not include all the possible explanations of mind-body relations. Many psychologists would refuse to accept either, but these views, as stated, serve to show the extreme conceptions of the part played by mental activity in determining behavior.[2] So far as the treatment of educational psychology as set forth in this volume is concerned, the student may accept either of these views, or some other if he prefers.

**Varying significance of mental activity as a factor in human responses.**—It was pointed out in the preceding chapter[3] that in a reflex act, which is one type of response, the transfer of the nerve impulse from sensory to motor neurones takes place in the spinal cord or at lower brain levels and that consciousness, which depends upon neural activity in the cerebral cortex, is therefore not an element in the total response. The organism may be conscious of the muscular activity involved in the response, but it is a consciousness after the act rather than before it, being due to a new set of sensory impulses from the muscles, tendons, and joints (and perhaps other sources) involved in the muscular activity.

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[1] This view is known as the *double-aspect hypothesis.* As an example of a textbook in psychology in which the double-aspect hypothesis is adopted, see WARREN, H. C.—*Human Psychology.* Boston: Houghton Mifflin Company, 1919. 460 pp.

[2] The behavioristic view is often regarded as the opposite extreme of the interactionistic view, since the behaviorist refuses to deal with mind or consciousness at all. His unwillingness to consider mental life is due, not primarily to a belief that mental phenomena do not occur, but rather to the conviction that, since mind cannot be studied by the objective methods of science, psychology can never occupy a position of respect among the sciences if it admits mental phenomena into its data. Hence he proceeds to study stimulus-response relations, defining response solely in terms of muscular and glandular activity.

[3] See page 49.

Even consciousness of the response after it is completed is not always present. Responses involving the muscles and glands connected with the digestive, circulatory, and respiratory systems are normally not reported in consciousness. These responses are very essential to the maintenance of life and are for the most part entirely beyond voluntary control. They may properly be regarded as belonging to the group of responses known as reflex actions, though they are sometimes listed separately as "physiological actions" or as "autonomic actions."

The responses in which consciousness is involved, however, constitute by far the larger part of human reactions. In extreme contrast with reflex reactions in which consciousness does not appear as an element in the response and thoroughly mechanized responses from which consciousness has practically disappeared,[1] there are other responses in which mental activity is the factor of supreme significance and muscular activity almost, if not entirely, negligible. For example, I see a schoolboy pass on his way to school. I am led to recall my first year of school life—the teacher who treated me so kindly, the boy who occupied the other half of the double seat in which I sat, the games we played in the schoolyard, the chart from which we learned the alphabet and the elements of reading. Or perhaps the sight of the lad sets me to wondering what his experiences during the day will be, what educative value they will have, what modifications our present-day educational practice may stand in need of, and so on. Or again, it may be that I am led to consider the hopes and visions which the lad's fond parents entertain for his future, the likelihood of their realization, the tendency of parents to dream that their children may achieve that which they themselves have missed, and so on. In each such case, the response may include incipient movements of the muscles of speech—i. e., subvocal talking—and possibly other bodily movements, but such muscular activity is relatively inconsequential in and of itself. The response is essentially mental activity.

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[1] Examples of such acts are walking, riding a bicycle, eating, dressing, writing, whistling, and dancing. In the earlier stages of acquiring skill in such performances, however, consciousness is a very significant element in the responses.

Most human responses lie somewhere between these extremes, that is, between reflex activity in which consciousness has no part and mental activity unaccompanied by significant muscular movements. In some cases the muscular element of the response predominates, in other cases the mental element constitutes the more significant portion of the reaction. But both elements are usually present, and hence we cannot, in strict accuracy, classify responses as mental and muscular. For the sake of convenience, however, we shall employ the term "mental response" when the conscious element characterizes the total response and "muscular response" when the conscious element is absent or relatively insignificant.[1]

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[1] It should not be forgotten that sometimes significant glandular activity is present in the total response.

**The simple stimulus-response relation not typical in human behavior.**—Thus far we have spoken of human behavior as if stimuli were encountered singly and separately by the organism, each stimulus producing a distinct, definite response. Such, however, is by no means the case. Stimuli of various kinds are constantly assailing the receptors and bidding for recognition, with the result that usually several stimuli coöperate in influencing behavior at a given time. The matter is further complicated by the fact that these stimuli do not arouse activity in a nervous system that is altogether quiet or passive until they stir it to action. The nervous system is never wholly at rest. Whenever a stimulus excites any receptor, therefore, the resulting nerve impulse is, so to speak, superimposed upon, or blended with, the neural commotions already in progress. An illustration may serve to clarify our meaning:

Jones is walking down the street on a beautiful morning, feeling his best, well pleased with himself, and kindly disposed toward his fellows. He is accosted by one less fortunate than himself, who says, "Mister, can you help a fellow out a bit? I'm in hard luck." Jones sees that the suppliant is seedy in appearance, rather well advanced in years, and apparently physically incompetent. He also notes that the beggar's breath carries an odor of strong liquor. Jones, it will be observed, has already made a number of responses, but the main response to the total situation—certainly the main one from the vagrant's point of view—remains to be made. What will it be?

No doubt various factors in addition to those mentioned will play a part in determining Jones' total reaction to the situation, but a sufficient number have been mentioned to show that the matter as a whole is complex rather than simple, from the point of view of both stimulus and response. It is very probable that, if any element in the situation had been different, the total reaction of Jones would have been modified. Suppose Jones feels compassion for the beggar and an impulse to bestow charity upon him, but fears that any money given him would be spent for liquor, and that his charity would thus result in further distress and incompetence, and therefore says, "I'm sorry, but I can't do anything for you." This response, at least from the point of view of the mental activity accompanying the speaking of the words, would have been different had Jones been in a different mood, or if the beggar had addressed him as "Buddy" instead of "Mister," or if he had been able-bodied, or if he had not given evidence of an appetite for drink.

The total neural state at a given moment, then, is likely to be a composite of a number of elements. In so far as the total neural state is reflected in consciousness, the mental response is correspondingly complex.

**Types of mental activity.**[1]—Consciousness, which is a general name for a complex of responses, has often been likened to a stream of water, and the analogy, if it is not pressed too far, is helpful in understanding the general character of mental life. Like a river, the stream of consciousness flows onward in ever-changing movements and configurations—here sluggish, there swift; now shallow, then deep; at one time calm and peaceful, at another moment turbulent and riotous. One mental state, or conscious process, follows another in rapid succession, no two being exactly alike, yet each related in some degree and manner to its predecessor and to its successor.

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[1] Although the term, activity, is used here as well as elsewhere, the reader should bear in mind that it is not spontaneous, but is, rather, a response to stimuli. He should also remember that usually and perhaps always there are concomitant muscular responses, but they do not appear to be important for our purposes here.

Although the stream of consciousness is complex and ever-changing, it may be analyzed, and certain types of mental activity identified. There is not perfect agreement among introspectionists as to the exact details revealed by their attempts at analysis, but certain types of conscious processes are rather generally recognized. Since we are concerned with the types of mental activity primarily for the sake of the light they may throw upon the learning process, we shall adopt the following classification which appears to serve our purpose best.[1]

1. Sensation
2. Perception
3. Memory
4. Imagination
5. Thinking
6. Feeling
7. Emotion
8. Reaction tendencies[2]

These types of mental response will be described in order in the remainder of this chapter. It should not be supposed, however, that these various types of responses always occur separately, and that the presence of one of them in consciousness thereby excludes all the others. On the contrary, the analysis of any given mental state is likely to show that a number of these responses are involved in it. They are discussed separately only for the sake of convenience and clarity.

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[1] For a somewhat different classification see Gates, A. I.—*Psychology for Students of Education.* New York: The Macmillan Company, 1923, Chapter V.

[2] The term "reaction tendencies," it will be seen later, is applied to a considerable number of somewhat heterogeneous, nondescript responses which are difficult to treat satisfactorily, yet which are of such great import that they cannot be disregarded in any attempt at an adequate explanation of human behavior.

✓ 1. **Sensation.**—It is very difficult to define sensations in any precise and meaningful way. This difficulty is largely due to the fact that, so far as the adult is concerned, and even the child very shortly after the beginning of conscious life, a pure sensation is an abstraction; it does not exist. Sensations, to be sure, are present in experience most of the time throughout conscious life; but they are not present alone—they are not pure sensations. The meaning of this statement may be illustrated as follows:

Just now I hear my watch ticking. The movements of certain parts of the watch produce air vibrations which excite the hair cells of the inner ear, thus arousing nerve impulses in the auditory nerve. These nerve impulses are conducted to the auditory centers in the cerebrum, upon whose activity hearing depends. As I listen to the ticking of the watch, then, sensations of sound are present in my consciousness. But my consciousness involves much more than sensations. I know what these sensations mean. I cannot hear the sounds without knowing that they *are* sounds and that they are caused by the watch. In a like manner, I may experience visual sensations if I look at the watch, or tactual sensations if I touch it, and so on. But in no case do I experience pure sensations, that is, sensations isolated from other conscious processes.

If the watch is held near the ear of a child shortly after birth, it is likely that some sort of consciousness is aroused.

His response to the sounds, however, is far different from mine. He does not know what they are or whence they come. His response is, at least approximately, a pure auditory sensation. Before long, however, auditory experiences become associated with objects in his environment, with the result that even an entirely new and strange sound has some meaning for him—suggests to him some object or source—and he therefore ceases to experience pure auditory sensations.

We may say, then, that sensation is being conscious only of some quality (visual quality, auditory quality, tactual quality, gustatory quality, and so on) of an object.[1] Sensations are present in all mental responses to stimuli exciting receptors. Hence there are as many classes of sensations as there are different kinds of receptors. The latter have been treated in Chapter II and need not be repeated here.[2]

The importance of sensations in mental life can hardly be overestimated. They supply the raw material out of which is constructed our knowledge of the world and of our own bodies. Any marked defect in one's sensory equipment, therefore, is likely to operate as a serious handicap in one's mental life and development.

2. **Perception.**—We have already suggested the nature of perceptual responses when we pointed out that, except in the case of very young children, sensations are always attended by some degree of meaning and indicate some object in the environment. Perception is the *consciousness of objects present to sense*, and the product of the proc-

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[1] One's own body is, of course, included among the objects of whose qualities one may be conscious.

[2] See pages 29f.

ess—that is, the sensations together with their meaning—is called a *percept.*[1]

The sensory and neural equipment necessary for sensations is ready to function at birth or very soon afterward, but perception depends upon experience; that is, it involves learning. The child does not, at the beginning of life, simply open his eyes and perceive persons, chairs, pictures, toys, doors, windows, and the like, some large and others small, some near and others far, and so on; he must learn to perceive such objects.[2] The story of his progress in building up his perceptual world is an interesting and instructive one, but space will not permit us to attempt to trace it here. If such an account were given, however, we should doubtless be impressed with the very great part that the child's movements play in the building of his perceptual world.

As a process, perception may be called the act of experiencing sensations and putting meaning into them. To illustrate, let us consider the development of the child's perception of his rattle. If we suppose that he first sees the rattle before any objects seen have meanings attached to them, his first experience with it is confined to visual sensations. In neural terms, we may suppose that only a very restricted area[3] in the brain is active in the experience. If he hears the rattle, another restricted area in the auditory center of the brain is aroused; and if he feels the rattle and shakes it, still other cerebral centers are called into activity.

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[1] Bagley has expressed this idea as follows: "Practically every perception of adult life is a complex of (1) sensations immediately evoked by external stimuli, and (2) sensations that are revived from past experiences." BAGLEY, W. C.—*Educational Values.* New York: The Macmillan Company, 1911, p. 29.

[2] Learning to perceive is described on pages 158f.

[3] This is, of course, the visual area in the occipital lobe of the cerebrum. See Figure 10, page 47.

There comes a time in the child's development, however, when the visual sensations aroused by the sight of the rattle have some meaning. They denote an object in his environment having a certain appearance. If he sees and hears it simultaneously, both the visual and the auditory centers of the brain are aroused and certain neural connections are set up whereby the sight of the object at a later time tends to recall the sound it makes, and conversely. Thereafter the visual sensations mean an object with a certain appearance and a certain sound. Similarly, if he sees and handles the rattle, further neural connections are formed, with the result that still further meaning is present when he sees or hears the rattle. Thus the process continues, his repeated experiences with the rattle gradually extending and consolidating the meanings he attaches to it. More and more associations are built around it, until, we may fancy, the child has reached a man's estate and becomes a toy merchant or a manufacturer of toys. What a stock of meanings the rattle then has attached to it! And what a complex organization of neural elements may be involved in the consciousness of the object!

The perceptual process, then, is one of change and development, and is not the simple matter-of-course performance that the adult is likely to think it is. In its various forms it represents an important type of mental activity. A child learns through perceiving and consequently perceptual experiencing is recognized as a type of learning activity.[1]

3. **Memory.**—It appears that a sensation leaves some mark, some effects, upon the brain-paths involved, as a result of which a mental state very similar to, yet less

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[1] See pages 203–04.

vivid and intense than, the original sensation may be experienced later if these brain-paths are aroused without the presence of the original stimulus. Faint copies, so to speak, of a sensation or a group of sensations may afterward appear in consciousness.[1] These copies we may call *images*. Thus you can probably "see in your mind's eye" the dining-room in your childhood home, or "hear" your mother's voice, though these sights and sounds may not actually have been present for months, or even years.

Not all sensory experiences, however, are revived with equal readiness or clearness.[2] Visual and auditory images are perhaps the most common forms. On the other hand, it appears that images of cold, warmth, heat, pain, and strain are relatively rare. Olfactory and gustatory imagery is not uncommon. There are marked individual differences in the facility with which various types of imagery are employed, but it seems that most people employ more than one type.

Conscious states, then, often result from the rearousal of brain-paths that have previously been active in response to some stimulus or group of stimuli. For example, I once saw a monstrous snake, some twenty-five or thirty feet long, in the act of swallowing a live chicken that had been given to it. I can, in a measure, re-experience the spectacle now, though far less vividly than on the original occasion: the coiling and squirming of the huge reptile as it attempted to force the luckless fowl through its distended jaws; its glistening skin, with a really beautiful pattern of colors (which, however, I can no longer make out); the proud and garrulous keeper in the pit with the snake; the loathing and disgust I felt for the reptile, as well as the sympathy for its helpless victim. Furthermore, in my present consciousness is the knowledge of the time and place at which the original experience occurred. Such is an act of true memory—a re-instatement of a former experience that is definitely located in the subject's own past.

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[1] This appearance is not spontaneous but a response to some stimulus. This stimulus, however, is not the one that produced the sensation. See page 148 for discussion of substitute stimulus.

[2] Bentley, Madison.—*The Field of Psychology*. New York: D. Appleton and Company, 1924, pp. 87f.

We shall use the term "memory," however, to include many cases of recalled experience in which there is no consciousness that the original experience had a definite temporal and spatial location in the past. If I am asked to tell who was chosen president in the election of 1860, I answer, "Lincoln." The political contest of 1860 is not a part of my own past, nor do I remember when I ever encountered the fact that Lincoln was the successful candidate. Whatever of past reference there may be in the answer is directed toward a period prior to any experience of mine. Again, if I am asked to tell how many feet there are in a mile, I answer "5,280" without any past reference whatever. Yet conscious states corresponding to these facts must have existed previously and must now be revived in the absence of the stimuli that were originally necessary for their production. Otherwise the answers would not appear promptly and without effort. All responses, then, which are repetitions of prior states of consciousness, but which are made independently of the stimuli that originally produced them, we shall regard as acts of memory. Thus we may speak of "remembering" the date of the battle of Waterloo, the names of the thirteen original colonies, the declension of *servus*, the "Psalm of Life," and so on through an almost endless list of acquisitions.

*Phases of memory.*—There are four phases of an act of memory: (1) impression, (2) retention, (3) recall, and (4) recognition. Since these are obviously important aspects of the learning process, it will be helpful to give some attention to each.

In order that a thing may be remembered, it must, of course, be first experienced. In other words, there must be an impression. Whether or not it will be remembered depends in part upon the character of the original impression. Next, some effects of this impression must be retained by the organism so that the essential aspects of the original experience can be recalled, or reproduced, in response to an appropriate stimulus. Finally, the thing recalled must be recognized for what it is, else it has little or no value. If I need to know the square of 19 and recall that it is 361, yet feel no assurance that this number is correct, the recall does not serve my purpose, since I must proceed by multiplication to determine whether or not the desired number really is 361.

In attempting to understand the four phases of an act of memory, it will be helpful to interpret the process in the light of the following assumption: *Whenever a neural tract is active, it is changed in some manner by this activity; and as a result of these changes, any later activity aroused in the tract tends toward a repetition of the original activity.*[1] In the light of this assumption, impression, or learning, consists in the production of neural changes and tendencies toward subsequent activity, and retention is the persistence of these changes and tendencies.

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[1] The latter part of this assumption may be stated in a somewhat different form that will be more helpful in some cases. A "neural tract," as referred to in the above statement, is in many cases to be thought of as a more or less complex grouping or organization of neurones, all of which are active in a given mental response. If to the smallest group or series of neurones which can coöperate in producing a mental response we apply the term "elementary neural process," we may then re-state the latter part of the assumption thus: *If two or more elementary neural processes are active simultaneously or in immediate succession, later activity in one of them tends to re-arouse the others.* See page 194.

Recall, however, is not to be explained so simply and briefly. Let us illustrate: Yesterday I happened to observe a collision between two automobiles at a certain street crossing. In accordance with the hypothesis advanced in the preceding paragraph, when I came to the same intersection this morning, the sight of it should have "set off" a train of neural activities in the same tracts that functioned yesterday, and I should have recalled the incident then witnessed. That I did not is due to the fact that I have had many former experiences in which this street intersection played a part. A year or so ago I witnessed an accident there in which a child was killed. Last month I met there a friend whom I had not seen for years. Frequently I meet another friend there and walk with him to the campus. Some time ago I watched the fire department battle with the flames as the building on one of the corners burned. Any one of these experiences may be recalled when I see this crossing. Which one will be recalled depends upon the relative strength of several factors, which we may call (1) vividness, (2) recency, (3) frequency, and (4) mental set. With respect to these factors we may state the following principles:[1]

(1) The more vivid an experience is, the stronger the tendency is for it to be recalled.

(2) The more recent an experience is, the more likely it is to be recalled.

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[1] To be precise each of these statements should be prefaced by the phrase, "other factors being equal."

(3) The more frequently an experience has been repeated, the stronger the tendency is to reinstate it.

(4) Of various experiences that may be recalled, the one in closest agreement with a person's present mental set[1] is most likely to reappear.

The retention effects of an experience, then, are influenced by several factors. Among these, the native retentiveness of the individual is undoubtedly an important one. It is an interesting question as to whether one's memory can be greatly improved by training. It appears likely that, even if native retentiveness is not materially affected by training, the methods employed in memorizing may be vastly improved with the result that one comes to remember more efficiently.[2]

Of the recognition phase of the process little need be said. Various explanations of the manner in which recognition of the image is brought about have been offered,[3] but a review of these explanations would serve no useful purpose here. We shall be content with saying that this phase of the process varies from recognition proper, as when I recognize my present memory image as meaning Theodore Roosevelt addressing the graduating class of which I was a member, to an almost unnoticeable feeling of familiarity attaching to the mental response "ohm" when I am asked to think of the unit in which electrical resistance is measured. Recognition or the feeling of familiarity in responses is important as an assurance, though not necessarily a guarantee, that the response is correct. The disturbing effect of the absence of recognition or feeling of familiarity tends to initiate efforts to verify the correctness of the response and, if necessary, to substitute another for it.

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[1] See page 100 for the meaning of this term.

[2] See SEASHORE, C. E.—*The Psychology of Musical Talent.* Chicago: Silver, Burdette and Company, 1919, pp. 236-37. Also ANGELL, J. R.—*Psychology.* New York: Henry Holt and Company, 1908, pp. 237–42.

[3] BENTLEY, *op. cit.*, pp. 255–57.

4. **Imagination.**—Imagination resembles memory very closely—so closely, in fact, that there are border-line cases which can hardly be distinguished. Some writers prefer, indeed, to regard memory as a special case of imagination—namely, the case in which the images are recognized as coming from the past without essential modification. Memory may then be called *reproductive imagination.* If, for example, I am asked to describe the appearance of George Washington, the image that appears in consciousness is recognized as a picture of Washington in the history text that I studied many years ago. It, therefore, is a memory image, and a part of my response to the request for a description consists in remembering a picture, which I then proceed to describe. But if I am asked for a description of a sunset scene among the Alps, I find no memorial image to aid me. I must therefore construct an image as best I can, without the consciousness that this image corresponds to some previous mental process. This may be called *productive*, or *constructive*, *imagination.* We shall use the term "imagination" only in the sense of productive imagination.

It is important to note that, in my constructed image of the sunset scene, no absolutely new materials can be employed. I can put into the image nothing that is not found in my past experience. But I can combine the elements or materials furnished by former experiences into an almost endless variety of forms.

Memory differs from imagination in that the memory image is accompanied by a feeling of familiarity or recognition, whereas no such feeling is present in constructive imagination. Another difference consists in the fact that memory has a past reference, while imagination may refer to the past, the present, or the future. I can imagine the scene at the execution of Joan of Arc, or the present appearance of Constantinople, or the home I should like to build some day.

Imagination is sometimes popularly conceived as involving only the unreal and the fanciful, as, for example, the creation of myths and fairy stories. According to this conception of the term, the poet or story-writer has great powers of imagination, whereas the business man or the scientist is more properly a hard-headed, matter-of-fact, unimaginative person. But such a view of imagination is far from correct. When the business man foresees the growth of business in his community, anticipates the increased demand for his products, pictures his business quarters as he wishes them to be when they are remodeled, expanded, or rebuilt, or devises any plans for the future conduct of his affairs, he is engaging in imagination just as truly as is the writer of fairy tales when he constructs a new account of the happenings to Prince Charming. So, too, is the scientist a man of imagination when he conceives molecules, atoms, evolution, gravitation, the ether theory of light, the nebular hypothesis, and the like. There is no type of mental activity that is of more value and importance in the realm of the real and practical affairs of life than is imagination.

Imagination occupies a very prominent part in the responses the pupil should make in school work. He is called upon at every turn—in history, in geography, in literature, in science, and even in mathematics—to picture to himself persons, places, events, things, forces, relations, and the like, which he has never experienced perceptually and never can so experience. In case he fails to imagine as freely, clearly, and accurately as he should, he will perforce be dealing with mere words, with the husks of learning without the kernels.

Clearness, accuracy, and range of imagination probably depend upon several factors. Obviously a wealth of sensory experience is needed as a source of the imaginal materials employed in the process. Furthermore, opportunities for imagining as clearly and accurately as possible should not be neglected. When one reads, for example, abundant opportunities for imaginational activity are present, but may be disregarded in one's haste to "get over" the lesson or to reach the end of the story. A large part of the time spent in study might well be devoted to the construction of clear images or "pictures" of what is being described or discussed.

5. **Thinking.**—Thus far we have dealt with mental responses as if only one mental act or conscious process—and it perhaps of only short duration—ever resulted from the application of a stimulus, or a group of stimuli, to one or more receptors. It is necessary now to emphasize the fact that such is by no means the case. A single excitation in a receptor may set up in the cerebral cortex a protracted movement of nerve impulses that are the neural correlates of a succession of mental processes. For example: I look out the window and see a tree; I am reminded of an arbor-day address I once heard delivered by a statesman of national prominence; next I find myself dwelling upon his failure to win the presidential nomination in the following convention of his party; a moment later I am thinking of

the last presidential campaign; this leads me to question what part religious prejudices may have played in influencing voters; then I think of William Penn and his colony in the New World; I next call to mind a football game in which the team representing the University of Pennsylvania participated. And so the succession of mental states may continue indefinitely if no interruption occurs.

The total response to the tree (or more accurately, to the light waves reflected from the tree) included a succession of mental acts beginning with the perception of the tree and ending with the memory of a football game. Most of the mental states in the series were memories, but such is not the case in all series of responses. Imaginational images may appear in the succession, or any combination of memorial and imaginational images may be present.

If we call an image plus its meaning or meanings an *idea*, we may say, then, that a single stimulus may result in a series, or succession, of ideas, each of which evokes, or calls up, another. When one idea is thus followed by another, the first is often spoken of as serving as a stimulus for the second.[1] If the question is raised as to how one idea can serve as a stimulus to another, a possible answer is found in the assumption stated on page 85. The neural activity which is the physical basis of the one idea contains some element which is also a part of the neural activity correlated with the second idea. Hence, activity in the first group of neurones tends to arouse activity in the second group.

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[1] According to our definition of "stimulus" (see page 68), this statement is incorrect, since an idea is not a form of energy external to the nervous system which can excite a receptor. When we say that one idea is a stimulus to another idea or to a movement, our meaning, in neural terms, is that the nerve impulse passes from one brain-tract, the activity of which is correlated with the first idea, to another brain-tract, the activity of which is the neural basis of the second idea. When we follow a rather common practice, therefore, and speak of one idea as the stimulus to another or to some movement, the reader will remember that the expression is not to be taken literally and that it is merely a convenient, though inaccurate, way of stating what actually does occur.

We shall apply the term "thinking" to those responses involving a train, or sequence, of ideas, or of percepts and ideas when some unifying factor is present, so that the entire sequence may be regarded as one response to some original stimulus. Thus, engaging in reminiscence or reverie is one sort of thinking. Such thinking as occurs in these activities we may call *spontaneous thinking*, by which we mean that the process goes on of its own accord without any feeling of effort or direction on the part of the person engaged in it. But often the process of thinking is accompanied by a feeling of effort, due to the fact that the person who is thinking has some purpose or end in view which exercises a directive influence on the sequence of ideas that appear. Under such conditions the ideas that appear in consciousness are determined in part by the purpose. In its most important and most difficult applications, this purposive, or voluntary, thinking takes the form of *problem-solving*, or *reflective thinking*.

*Reflective thinking a response to a perplexing situation.*—This type of thinking is a response to a perplexing situation such as a difficulty, a need, or a question for which a person is not able to recall a ready-made answer.[1] Such stimuli are not limited to the classroom. They occur in all fields of human activity. The choice of a college may become a problem for the high-school graduate; the choice of a vocation is at some time the problem of the college student. Many occasions for reflective thinking arise in the course of activities of life. For example, What kind of a vacation can I have on the resources available? Knowing my usual average time for driving to my home, which way shall I take with two hours' time before an engagement? What make of radio should I purchase? Shall I buy on the installment plan or wait until I can pay cash?

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[1] The reader should not infer from this statement that the response to a difficulty is always characterized by reflective thinking. A person may respond without thinking or even make no response at all, but this type of thought process occurs only in response to such situations.

*The phases of reflective thinking.*—The response, which is called reflective thinking, is commonly described in terms of the following steps or phases:

1. Defining the problem
2. Collecting data or information pertaining to the problem
3. Forming a hypothesis or proposing a tentative solution
4. Verifying the proposed solution

In defining a problem one endeavors to get clearly in mind exactly what the difficulty is, or precisely what questions are to be answered. In geometry students are frequently asked to state formally, "What is given?" and "What is to be proved?" Although such a formal statement is not usually required in other fields, the answering of these questions constitutes a prerequisite step in the solving of a problem. A well-defined problem serves as a guide throughout the remainder of the process of solving it. Without a clear understanding of the conditions given and the particular question or questions to be answered, a student's mental activity will be aimless and consequently probably fruitless.

In many instances sufficient information relative to the problem under consideration may be recalled by the student from his past learning. When this source is inadequate, additional information may be sought through reading or through inquiry of persons, or, in some cases, data may be secured from original sources. The collecting of information frequently is a comparatively simple task, but sometimes it is difficult and requires much skill and patience on the part of the student. Because this step at times becomes very prominent in the solving of a problem, students have a tendency to consider it as completing the solution. They fail to realize that the ideas, facts, and principles which they have collected are only the raw materials out of which they are to develop their answers by formulating and verifying hypotheses.

A hypothesis is merely a proposed solution. It may be right or it may be wrong. It is a "guess" at the answer, but the skillful reasoner bases his "guesses" upon the definition of the problem and the data collected. Frequently a hypothesis occurs to the problem solver before he has completed collecting data. At other times his ingenuity may be taxed to formulate a tentative solution even after all of the data are at hand.

The final step is testing the proposed solution. A hypothesis must be considered tentative until it has been proven to be satisfactory. The process of verification includes comparison of the hypothesis with the conditions of the problem, with all the data collected, and with any other facts or principles which may be relevant. In case the first proposed solution is found to be unsatisfactory, another hypothesis must be made and the step of verification repeated. This procedure must be continued until a solution is discovered which will pass all of the tests that the problem-solver is able to apply to it. Many students exhibit a tendency to "jump at conclusions," that is, to accept the first hypothesis which comes into their minds.

It should, however, be apparent that to omit the verification of the proposed solution is to stop before the act of reflective thinking is completed. An unverified hypothesis may be right, or it may be wrong. In other words, the problem may have been solved, or it may not have been.

The reader should avoid the inference that reflective thinking is an orderly process in which these four phases stand out clearly. It is rather mental exploration. During the process there is a searching for ideas and a trying out of hypotheses. The process resembles the trial and error responses that occur in sensori-motor learning.[1] It should be noted, however, that reflective thinking is not a random exploration. The trial and error process is guided by the problem. If it is not, the thinking cannot be classified as reflective.

It should also be noted that the four phases of reflective thinking overlap. Sometimes a problem is not adequately defined until after one or more hypotheses have been made. Frequently, as stated before, hypotheses are formed before all of the data have been collected. Occasionally one or more of the four steps may appear to be omitted, because of the fact that the "thinker" has been able to take a "short cut." For example, suppose a historian is asked a relatively easy thought question[2] in his field of specialization. If the question is stated clearly and concisely, the defining of the problem may be completed in the comprehension of the verbal statement. Since the question is in his field of specialization, the historian may appear not to think reflectively, that is, he may give his answer promptly and fluently. But if we had a complete record of his thought processes, we would probably be able to identify each of the four phases.

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[1] See pages 153f.

[2] A thought question is one for which the person responding does not have a ready-made answer.

*Relation of thinking to perception, memory, and imagination.*—It has doubtless occurred to the reader of the preceding pages that thinking overlaps or even includes perception, memory, and imagination. This is true, but thinking is more than merely a combination of perception, memory, and imagination. Reflective thinking is the name given to a certain type of response to a perplexing situation. Its significant characteristics are the four phases described in the preceding pages.

6. **Feeling.**—The conscious states thus far described as responses to stimuli are accompanied by a subtle and indefinite element of consciousness commonly called *feeling*. For example, if as you read this sentence you image an article of food that you enjoy eating, your state of consciousness probably will include a feeling of pleasantness. On the other hand, if you think of some article of food you dislike, you will experience a feeling of unpleasantness. The strength of the feeling varies. In some cases, the feeling may dominate the conscious state. For example, a weary and hungry traveler thinks of reaching his destination within an hour. The image of his destination includes "a room and bath," and an appetizing dinner. The entry of this image into the traveler's consciousness is accompanied by a strong feeling of pleasantness. Another person who is tired of hotels and the food they offer finds it necessary to make a trip that necessitates spending two or three nights in a hotel whose accommodations have been found to be unsatisfactory on previous occasions. Under such conditions the image of "a room and bath" and a dinner is accompanied by a strong feeling of un-

pleasantness. In other cases the feeling may be relatively weak. In fact, an untrained introspectionist may say that there is no feeling. This condition often prevails in doing or thinking of commonplace things, such as brushing the teeth, walking, dressing, and the like.

This element of consciousness is called "affective" to distinguish it from the sensory and ideational elements. Several theories have been proposed as explanations of the source of feelings. Some authorities have explained feelings as complexes of organic sensations resulting from internal or organic action induced by the sensory and ideational states. Another theory now widely accepted is that the cause of feeling is in the condition of the neurones involved in the conscious process. If one condition exists, there is the feeling of pleasantness; if the opposite condition exists, the feeling is unpleasant. The precise nature of these conditions is not known. Thorndike describes them as "readiness to act" and "unreadiness to act." If a neurone is "ready to act," to act is pleasant and not to act is unpleasant. For a neurone which is "unready to act" to be forced to act is also unpleasant. For example, when the bell rings at the close of a class period, the pupils find it unpleasant to remain longer in the classroom and to attend to the discussion. There is a "readiness to act" in the direction of departure from the room, as well as an "unreadiness to act" with respect to the work of the period. Thus, other things being equal, readiness to act constitutes a "mind set" that is favorable, and unreadiness to act one that is unfavorable, toward the response in question.

**7. Emotion.**—A seventh class of responses to situations are called emotions, which have been aptly described as "stirred up states of the organism." We seem to have ideas but emotions seem to have us. Emotions have almost invariable muscular concomitants. Such expressions as the thrill of pleasure, the shiver of fear, the expansive adjustments of joy, and the bristling of anger suggest the multiform muscular responses closely associated with certain emotions. This close association has led to two widely held views of the relation of emotions to the physical mechanism. One, the Lange-James Theory of the Emotions,[1] asserts that the emotions are nothing more than the feelings resulting from certain physical responses to a situation. According to this theory, the running away produces the emotion of fear. The other view is not attributed to any man or group of men but is even more widely held than the Lange-James theory. According to it the emotions, or many of them, are the invariable concomitants of instinctive responses,[2] and the making of an instinctive response[3] is accompanied by a type of mental activity that we call emotion.

We know now that the concomitance between the emotions and the physical responses is due to the autonomic nervous system described in Chapter II, page 50. The essential cause of certain emotions we know to be the presence of the secretions of certain glands. For example, the secretion of the adrenal glands is responsible for such states as fear, anger, and zeal. (See page 60.) This new knowledge has led to a theory of the emotions which seems more plausible and is of much more significance to education than either of the aforementioned theories. This is the emergency theory proposed by Cannon.[1] The essence of this theory is that when a person encounters certain stimuli or situations the resources of the body are mobilized for an unusually strong response. For example, a child encounters a strange and terrifying animal. His muscles are supplied with blood even though the digestive tract be robbed. Digestion ceases, the heart beats more vigorously, breathing is deeper. Thus his resources are mobilized for flight. On another occasion the child may be opposed in his activity or desires. Again his resources are mobilized for action and as a result he is able to perform unusual feats. According to the emergency theory the affective phase of the total experience in such cases is described as an emotion.

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[1] LANGE, C. G., and JAMES, WILLIAM.—*The Emotions.* Baltimore: Williams and Wilkins Company, 1922. 135 pp. Edited by KNIGHT DUNLAP.

[2] McDougall has made a very clear statement of this theory. McDOUGALL, WILLIAM.—*An Introduction to Social Psychology*, Revised Edition. Boston: John W. Luce and Company, 1926. 513 pp.

[3] See pages 121f. for discussion of instincts.

There are many other theories and points of view concerning the emotions. Of these, the theories held by Freud and his disciples deserve mention but cannot be elaborated here. According to Freud's view the emotions are all related to a master emotion or instinct, the *libido*, which is the basic desire for preserving the race through reproduction. A self-preservative instinct is also recognized.[2]

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[1] Cannon, W. B.—*Bodily Changes in Pain, Hunger, Fear, and Rage.* New York: D. Appleton Company, 1915. 311 pp.

[2] There is much more to this theory including an elaborate technique for treating emotional disorders. Freud and his followers recognize that the emotion is always a part of the person's experience and related to his past experience. In other words, mature persons seldom experience primitive emotions. Almost all of their emotional experiences are related to their sentiments. Such sentiments as patriotism, friendships, liberalism, conservatism, academic or philosophic bias, antipathies and enthusiasms are largely responsible for, and often engulf, our emotions. But the emotions preceded the sentiments in their origin. Hence the early emotional experiences of children are very important educationally. Furthermore, the emotions as well as the more simple feelings and the more complex sentiments are very important to the teacher because of their

The importance of emotions in human life can hardly be overestimated. In the first place they are intimately connected with powerful controls of conduct.[1] To recognize the truth of this statement, one needs only to recite the names of a few emotions—anger, love, hate, fear, jealousy, pity. Again, the general trend of one's emotional, or affective, experiences largely determines whether or not one finds life worth living. Finally, it may be noted here that emotional strains and shocks are a prolific cause of mental disease and inadequacy, of which we shall say more in a later chapter.[2]

**8. Reaction tendencies.**—Many responses, or parts of responses, of great importance in behavior and in learning do not seem to be adequately provided for under the types thus far considered. Various writers in the field of psychology have employed such terms as "mind sets," "postures," "inclinations," "determining tendencies," "predispositions," "neural trends," and "preparatory reactions" to denote factors that frequently must be considered in accounting for human behavior. These expressions may be used to express slightly different shades of meaning, yet all of them suggest a readiness, or favorableness, or "tuning," on the part of the individual toward some further particular response, or a response of a certain general sort. All such responses, or partial responses, as those just mentioned we shall call *reaction tendencies.* The affective element tends to be prominent in at least some of this group of responses and hence they bear more re-

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relation to moral and esthetic development. The motives for learning are largely affective in their character. The emotions are probably the most obscure of our experiences, but by no means the least important.

[1] See pages 121f.

[2] Chapter XIV, pages 562f.

semblance to feelings and emotions than to the other types of conscious processes we have described.

One general characteristic of reaction tendencies should be emphasized. They are described here as responses to situations, but they in turn direct, or modify, the other responses that a person is making. For example, if a person meets a stranger who arouses what is commonly called a "feeling of prejudice," the effect of the presence of this reaction tendency will be to determine in part the other responses that may be made to the stranger. If a boy encounters a difficulty that arouses a "spirit of determination," his responses will be different from those that he would have made if this reaction tendency were not aroused. Since the purpose of this chapter is to describe the responses of human beings to stimuli, the following description of certain reaction tendencies will be confined largely to their characteristics as responses. The way in which they control other responses will be considered in Chapter IV.[1]

The term "reaction tendencies" is used here as a name for a rather large class of responses, but it appears to be sufficient for our purpose to describe only a few. Consequently the following have been chosen:[2]

a. Attention
b. Interest
c. Confidence
d. Determination
e. Openmindedness

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[1] See especially page 140.

[2] These reaction tendencies are closely related to personality or character traits. The measurement of these traits is considered in Chapter IX, pages 330–35. It may be helpful for the reader to examine these pages in connection with the study of the present topic.

*a. Attention.*—Ordinarily one is conscious, at any moment, of a number of things, but is more vividly or clearly conscious of one of them than of any of the others. For example, if one is observing the playful movements of a squirrel in a tree, the squirrel is the central thing in consciousness, but the observer is likely to be aware in some measure of other objects in the field of vision, as the tree, perhaps neighboring trees, the approaching automobile, the person walking down the street, and so on. That is, in any total state of consciousness, the various processes involved exist in different degrees of clearness and vividness. This fact is usually expressed by saying that one process is focal, that is, is clearest or most distinct; while the others, which are marked by lesser degrees of clearness, are marginal. This organization of consciousness with respect to clearness is called attention.[1]

But to speak of attention merely as the clearness aspect of consciousness does not seem to tell the whole story. Attention is, in the language of Woodworth,[2] ". . . an attitude of readiness for what is coming next. . . . Attention is preparatory, selective, mobile, highly conscious. To attend to a thing is to be keenly conscious of that thing, it is to respond to that thing and disregard other things, and it is to expect something more from that thing." Thus, the pupil who is attentive to his teacher's words is more favorably set or tuned toward hearing and understanding the next sentence she speaks than is another pupil whose attention at the same moment is centered upon the caricature of the teacher which he is surreptitiously drawing.

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[1] It should be noted that attention is not a power or force which brings about the varying degrees of clearness in the contents of consciousness. It is simply a name for the fact that such a state does exist. But the attention aspect of a given state of consciousness may be an important factor in determining further responses.

[2] Woodworth, R. S.—*Psychology.* New York: Henry Holt and Company, 1921, p. 244.

Attention is a rapidly shifting reaction tendency. It is impossible to maintain a given attention pattern without change for more than a few seconds. Elements of the pattern that are marginal at one moment may become focal at the next, or some entirely new element or group of elements may be introduced. To sustain attention to any object or event, therefore, it is necessary that new aspects, new qualities, new details be regarded.

Furthermore, the range of attention—that is, the number of objects which can be attended to at the same time—is limited. Titchener[1] states that the upper limit is six impressions "of a relatively simple kind and of unitary character." But if we raise the slightly different question as to how many acts requiring close attention one can carry on simultaneously, it appears that the answer is one. The rapid shifting of attention, however, may make it possible to keep two or more processes going by giving momentary attention first to one and then to another.

The attention response is in part native and in part acquired. The child instinctively attends to certain stimuli, such as moving objects, bright lights, bright colors, and loud sounds. In such cases there is no feeling of effort accompanying the attention. We say that the attention in such cases is *spontaneous*. But not all attention is spontaneous. Often a very marked feeling of effort is present. If history, for example, makes no appeal to the pupil, he may find that attention to it is annoying and seems to require genuine effort on his part. Such attention is called *voluntary.* It often turns out, however, that continued voluntary attention results in a change in the pupil's attitude toward history. The feelings of annoyance and effort gradually disappear. History may come to possess such an appeal that it is attended to spontaneously. We may classify attention responses as follows:[1]

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[1] Titchener, E. B.—*A Text-book of Psychology*. New York: The Macmillan Company, 1910, p. 287.

(1) Spontaneous
    a. Native, or instinctive
    b. Acquired, or habitual
(2) Voluntary

*b. Interest.*—Closely connected with attention is the reaction tendency commonly designated as interest. In fact, it may be thought of as the pleasurable feeling that accompanies attention. It is helpful, however, to recognize interest as a separate reaction tendency. We say of a child that he is interested in a toy he is playing with. By this statement we designate a phase of his response to the toy. An adult is interested in birds. When this adult sees a relatively rare bird his response includes interest. A student is interested in geometry. This means that he experiences feelings of pleasure or satisfaction in attending to geometry. Other things being equal, he is more likely to attend to geometry than to attend to something else that does not yield pleasure. That is to say, interest is both a pleasurable feeling that accompanies attention to a thing and also a reaching-out for more of that thing. To be interested in something is to be favorably disposed toward attention to it, and hence toward further responses to it.

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[1] Other terms have been used to denote these kinds of attention. Thus, Colvin and Bagley speak of "passive" attention, which may be either "primary" (i.e., native) or "secondary" (i.e., acquired), and "active" (or voluntary) attention. (See Bagley, W. C., and Colvin, S. S.—*Human Behavior.* New York: The Macmillan Company, 1913, Chapter IV.) Titchener speaks of three "stages of development" in attention—(1) primary, (2) secondary, and (3) derived primary. *Op. cit.*, p. 275.

Since most learning depends upon attention, and since interest leads to attention, it follows that interest facilitates learning. Other considerations than interest may, of course, result in a high degree of attention to a task. There is abundant experimental evidence showing that learning proceeds more rapidly when such incentives as prizes, rewards, records of progress, group competition, and the like are employed. For example, Wyman[1] devised a test of interest and administered it to a group of 81 children, who were also given the National Intelligence Test and the Stanford Achievement Test. The correlation between intelligence and achievement, when the effect of intellectual interest was eliminated, was found to be .76 and the correlation between intellectual interest and achievement, when the effect of intelligence was eliminated, was .49. These findings indicate that, although interest is somewhat less influential than intelligence in determining achievement, it is a very potent factor.

But, while interest facilitates learning, one can be attentive—and hence can learn—without interest. Lack of interest in a subject, therefore, does not wholly preclude the possibility of learning that subject. The spontaneous attention resulting from interest, however, renders learning more economical than when attention is forced, since in the former case all the energy devoted to the task is expended directly upon the learning, whereas in the latter case a portion of the energy is expended in maintaining attention.[1]

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[1] TERMAN, L. M., and others.—*Genetic Studies of Genius*, Vol. I. Stanford University: Stanford University Press, 1925, Chapter XVI.

*c. Confidence.*[2]—This term is used here with a meaning somewhat different from that which is ordinarily attached to the term "self-confidence." The latter term implies that the individual is conscious in some degree of himself, and is assuming, if he does not really possess, a faith in his powers to cope with the situation at hand. It is, as Dewey says, ". . . a form of self-consciousness—or of 'cheek.'" But confidence, in the language of the author just quoted, is ". . . not conscious trust in the efficacy of one's powers but unconscious faith in the possibilities of the situation."[3]

Recognition of "unconscious" confidence as a type of response is implied in the terms *introvert* and *extrovert.* An introvert manifests hesitancy, shrinking, confusion, embarrassment, and all the characteristics of the novice and the bungler. His performances may be likened to the movements of a machine in which the motions are impeded by excessive friction. On the other hand, the behavior of an extrovert, a person who makes a confidence response to the situation, is characterized by lack of hesitancy, confusion, and embarrassment. Such a person acts as if he were certain the outcome of his endeavors would be successful. Thus introversion and extroversion are merely opposite types of the confidence response. The introvert commonly makes one type of response to situations, and the extrovert makes the opposite type of response.

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[1] Thus Titchener speaks of secondary (i. e., forced) attention " . . . as a stage of transition, of conflict, of waste of nervous energy, though it appears at the same time as the necessary preliminary to a stage of real knowledge." (*Op. cit.*, p. 276.)

[2] A helpful discussion of this reaction tendency will be found in DEWEY, JOHN. —*Democracy and Education.* New York: The Macmillan Company, 1916, pp. 204–5.

[3] *Ibid.*, p. 205.

It is not an accident that faith is numbered among the cardinal Christian virtues, nor is it of less moment in temporal affairs. Without it great undertakings that require the support of all of one's powers are not begun and carried through to completion. Confidence, or unconscious faith in oneself, is nourished by consciousness of repeated successes and dwarfed or smothered out by habitual failures. Teachers and parents should be heedful of this matter, for training that leaves the pupil hopeless, spiritless, and without faith in himself has done more harm than good.

*d. Determination.*—Some persons are described as "determined." By such a description we mean that in responding to many situations a person exhibits a "set" or "bent" favorable to the pursuit of a particular course of action—so favorable, perhaps, that minor obstacles will not suffice to change the course. This is particularly true when one is influenced by some motive, or has some purpose in view toward which the action is directed. If the motive or the purpose is a very deep and powerful one, the determination tends to be correspondingly strong and is likely to persist in spite of temporary blocking or hindrance to the action. If, for example, one has a strong desire or purpose to graduate from college, his general course of action for several years, and his responses to many situations encountered during this period, are thereby determined.

Often the determination takes the form that we call "impulse." By this term we mean a conscious tendency toward immediate action without any consideration of the results of the act. Thus, if someone arouses our anger, we may feel an impulse to strike him. If we are in a crowded building and the alarm of fire is given, we may feel an impulse to rush to an exit. The child is especially impulsive in his acts, since he has not the foresight necessary to a consideration of the results of his acts. An important part of his education consists in learning to inhibit many impulses and in considering the consequences of various possible actions before making a choice. This is equivalent to saying that the child needs to learn to make a different kind of determination response to certain situations.

*e. Open-mindedness.*—The reaction tendency designated as open-mindedness is a disposition or readiness to give due consideration to all available facts and evidence bearing upon a given case before arriving at a conclusion with respect to it. For example, consider A who is asked whether he will support a certain candidate for a public office. If he does not know the candidate intimately and makes the response of open-mindedness to the question, A will reply that he cannot give an answer until he is informed concerning the candidate's fitness for the office. Or suppose A knows the candidate and replies in the affirmative. Later he is approached by B who believes the candidate is not fitted for the office and presents evidence to support his opinion. If A makes the response of open-mindedness to B's evidence he will give it due consideration and reverse his decision if he believes the facts justify such action. Open-mindedness is the opposite of prejudice. The prejudiced individual judges in advance of the evidence; and, having judged, he is no longer able to give the case a fair hearing.

Open-mindedness, then, is no mean trait; and, by that token, it is not easily and quickly acquired. Feeling and emotion may be its deadly foes. We are possessed of our wishes, our hopes, our desires, and our fears; and, as Cæsar long since pointed out, men very readily believe that which they wish to believe.

Like the other reaction tendencies thus far discussed, open-mindedness may follow as a response to some situations and not to others. One may, for example, be open-minded with respect to unsettled questions in biology, but strongly prejudiced in matters of politics. The character of his further responses when considering rival hypotheses in biology will be markedly different from the character of his further responses when considering rival issues or candidates in a political campaign. In the former case he welcomes new facts, no matter which theory they support, and gives to each fact the significance it seems to merit on the basis of a genuinely intellectual judgment. But his responses to matters bearing on political questions are of a wholly different kind. Facts that are favorable to his opponents do not receive a fair hearing, while considerations in support of his party are given an exaggerated value.

**Concluding statement.**—We have attempted in this chapter first, to arrive at some conception of the extremely varied and complex character of human responses to stimuli—especially those responses which we call conscious processes or mental activity—and second, to classify these mental responses and characterize each class. At the basis of mental life we found sensation, which early in life passes over into perception. Through perception our immediate knowledge of the world is acquired. All perceptions leave some mark on the nervous system, and many of them can be re-experienced as memories or modified into new forms of experience called imaginations. These, in turn, may appear in consciousness in series or sequences, subject to the laws of association acting under the influence of present purposes or problems. Feeling was described as a concomitant affective response, and emotion as a "stirred up state of the organism." Finally, we pointed out a number of loosely defined responses, called reaction tendencies, which color or shape all further responses made to the given situation. We thus have a helpful background for gaining some understanding of the learning process.

We believe nowadays in a universe of law and order, in which nothing happens by chance. We believe, too, that human responses are no more matters of chance than the happenings in the chemist's test-tube and retort are matters of chance. Mental processes are events of a natural, not a supernatural, order. The relation of cause and effect holds in the mental realm just as in the physical world. The factors present are doubtless more complex and certainly more difficult to identify, control, and measure. But we shall make progress toward the ultimate goal of psychology—namely, the prediction and control of human behavior—only as we can identify the factors that operate and explain the effect of each. We believe, then, that in some manner human responses are determined, or controlled; that is, some influence or group of influences controls the response which a human being makes to a given situation. We turn in the next chapter, therefore, to a consideration of the question, What are the controls of human responses?

## LEARNING EXERCISES FOR THE READER

1. Which seems to you to be more tenable, the double-aspect hypothesis or the interaction hypothesis? Why?
2. Point out respects in which the "stream of consciousness" differs from a stream of water.
3. Show by an example, real or imagined, that many or even all of the types of mental responses listed on page 78 may be present in a single total response to a situation.
4. Mention a few responses by adults that approach, as closely as any responses you can think of, pure sensations. Show in each case that the response is something more than sensation.
5. Read: Sidis, Boris, and Goodhart, S. P.—*Multiple Personality*. New York: D. Appleton and Company, 1904, pp. 91–127. This is an account of an adult, a Rev. Mr. Hanna, who, as the result of an accident, was forced to rebuild his perceptual world. What light does this account throw on the child's perceptual development?
6. Illustrate the difference between memory and imagination.
7. Should the child's powers of imagination be encouraged or repressed? Justify your answer.
8. Give an illustration, real or imagined, of a case of thinking in which both memory and imagination are prominent.
9. Are "thinking" and "problem-solving" synonymous? Explain.
10. Describe some case of problem-solving and show that the four phases mentioned on page 93 are present.
11. How does the definition of response in this chapter differ from Warren's definition? (See *Human Psychology* or *Elements of Human Psychology*.) Which definition seems preferable to you? Why?
12. Comment on the statement that the ultimate goal of psychology is the prediction and control of human behavior. How does prediction differ from control?
13. How are the prediction and control of human behavior related to teaching?
14. What bodily conditions and expressions accompany anger? Fear? Love?

15. Should the school teach the pupil to think (in the sense of reflective thinking, or problem solving) or teach him so that he will not need to think? Explain.

16. Describe a case, real or imagined, of a response to a situation in which five significant elements or factors are present. Show that, if any one of the elements had been different, the response would also have been different. (See pages 76f.)

17. In what respects does the thinking required in mathematics differ from the thinking that may occur in the social sciences? Which of these fields offers the better opportunity for problem-solving as described in this chapter? Explain.

18. What are the characteristics of a good thinker?

19. Prepare a list of the types of responses described in this chapter. For each type give two illustrations not given in the text.

20. Is the term "mental activity" appropriate? What is the argument against its use? Is it incompatible with a response psychology? Why?

21. What is a fact question? A thought question? Is the distinguishing characteristic of these types of questions to be found in the question or in the process of answering? What would be a precise label for a group of questions commonly designated as "thought questions"?

Ramona Hayler Ransbury

Lucy Bowen

# CHAPTER IV

## THE CONTROLS OF HUMAN RESPONSES

**The problem of this chapter.**—The response a person makes to a given stimulus is not a matter of chance. An adult is equipped with controls of conduct such that one who knows the training another has received can predict with a high degree of certainty the overt, or observable, elements of the responses he will make to certain stimuli. For example, the present writers probably could predict correctly the reader's verbal responses to such questions as: "Who was the first president of the United States?" "In what state is Chicago located?" "What is the ratio of the circumference of a circle to its diameter?" They could predict much less accurately his responses in such situations as the following: Finding a purse containing money but no information in regard to the identity of the owner; attending a bargain sale in a crowded store; witnessing a basketball game in which one hopes a particular team will win; driving an automobile in traffic; listening to a symphony concert. A person who is intimately acquainted with the reader could make much more accurate predictions, even though he probably would not be correct in all cases. But even if the response to a given situation cannot be predicted, it is nevertheless the product, or resultant, of certain factors or influences within the individual which operate to bring about *that* response instead of some other one. In other words, human beings are equipped with controls of conduct which determine the responses they make to stimuli. The problem of this chapter is to describe these controls of conduct.

**The neural basis of controls of conduct.**—It may be well to remind the reader once more of the exact meaning to be attached to the term "response." By response is meant the total activity that follows in the organism when a stimulus or a group of stimuli act upon one or more receptors.[1] The nerve impulse thus aroused is conducted into the central nervous system and thence, usually, out over motor neural paths to produce muscular activity or glandular secretion, or both. During its passage through the central nervous system it may be conducted through neurones in the cerebral cortex, thus giving rise to conscious processes. The two most significant aspects of the total response are (1) conscious processes and (2) muscular and glandular activity. For the sake of convenience, these are spoken of as "mental responses" and "muscular responses" (or "glandular responses" when these are significant), although in strict accuracy each of these expressions ordinarily denotes only a part of the total response.

The striped muscles can contract only when excited by nerve impulses from the central nervous system. The precise nature of the muscular responses, therefore, is determined by the distribution of the impulses carried by the motor neurones. The distribution of motor impulses is, in turn, determined by neural connections in the central nervous system. Hence we may think of the controls of muscular responses as certain conditions in the synaptic connections in the brain and spinal cord.

It is further assumed that mental responses also are dependent upon the cortical paths followed by nerve impulses, and thus upon synaptic connections. In other words, each different pattern of cortical excitation is correlated with its own particular conscious state. If this assumption is true, then all controls of conduct[1] are, in the final analysis, states of neural organization, or, in other words, series or systems of synaptic connections.

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[1] See page 68.

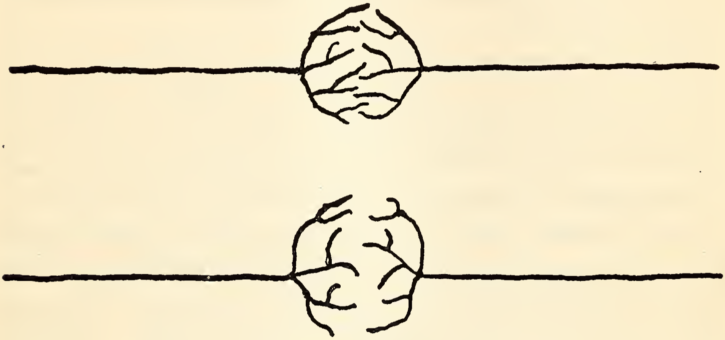

Figure 11. Schematic Representation of Synaptic Conditions That Are Favorable (Above) and Unfavorable (Below) to Conduction.

The synaptic status that facilitates conduction is not definitely known, but its effect may be illustrated by Figure 11. In the upper portion of the diagram the brush end of one neurone is shown in close contact with the dendrites of another. In the lower portion of the figure, there is a marked gap between the two neurones. Obviously the former condition would facilitate conduction and the latter would oppose it.

It is, of course, impossible to look in upon the nervous system at work and identify the synaptic connections responsible for a particular mental act or a complex muscular response. When the functioning of the neural path is attended by conscious processes, therefore, we find it far more illuminating to consider the controls of conduct in mental terms than to confine our descriptions to neural connections that cannot be observed. When, however, the response does not involve consciousness, as for example in reflex acts, we are obliged to speak of the controls in neural terms only.

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[1] The term conduct is used here as a general name for responses, both muscular and mental.

**Native versus acquired controls of conduct.**—In describing controls of conduct, psychologists usually distinguish between those that are native, i. e., a phase of a person's nature, and those that are acquired as the result of experience. Among the controls of conduct listed as native are those that determine the responses called reflex acts. For example, a chick pecks at small objects. The impulse originating in its optic nerve travels to the muscles involved in the movement called pecking. This response is determined by the chick's original nature. Similarly the young baby reaches for objects that it sees. When a person passes from a darkened room into sunlight, the irises of his eyes contract. In each of these reflex acts the path of the nerve impulse is determined by inborn synaptic connections in the person's nervous system.

On the other hand, a person's responses to such questions as those given in the first paragraph of this chapter are determined by acquired controls of conduct. In the absence of appropriate training, a person's total reaction would terminate in an incorrect verbal response, or in his saying that he did not know, or in no verbal response. Native equipment could not produce the correct response.

The distinction between native and acquired controls of conduct is not, however, as clear cut as these illustrations may suggest. Many native controls become modified,[1] some only very slightly, others extensively. On the other hand, all acquired controls have a native basis. When we speak of native controls we usually mean those that have been modified relatively little and hence are predominantly native. Acquired controls are those to which training has made a large contribution.

**General description of native controls.**—It is impossible, in the case of most responses a human being makes, to specify the exact degree to which each is due to native controls of conduct. Modification of innate tendencies toward reactions begins with the beginning of life, and soon native controls are inseparably fused or blended with the effects of previous responses. Hence authorities differ in their interpretations as to the relative contributions of inborn tendencies and of learning in the case of many responses. There is fairly general agreement, however, that the following responses[2] are to be explained primarily on the basis of inborn neural connections: pupillary contraction to increased intensity of light, sneezing, grasping, hiccoughing, walking, producing vocal sounds, eating, attending to moving objects, manipulating objects, play activities, fear responses to loud sounds, sex-behavior, fighting, and imitating some acts performed by other people.

A consideration of these responses readily reveals the following significant differences among them:

1. Some can be made almost from the hour of birth, whereas others do not appear until years later. For example, if the palm of the new-born baby's hand is touched,

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[1] The process by which this occurs is described in Chapter V. See page 149.

[2] This list is, of course, only a brief sample and is not to be regarded as in any sense exhaustive.

the fingers close upon the object. But certain sex responses do not appear during the early years of life.

2. Some of the responses are very simple—that is, only one muscle, or at most a very few muscles, are active—while other responses involve most of the muscles of the body. Thus the pupillary reflex may be contrasted with many play activities or with fighting.

3. Some of the responses are modified little, if at all, by training or experience, while others may be modified almost beyond recognition or even suppressed. The pupillary reflex again furnishes the best example of the former, though hiccoughing is not greatly changed by experience. Sneezing exhibits a somewhat greater degree of modifiability and subjection to voluntary control. A much larger measure of modifiability is present in sex-behavior and fighting responses, which are usually widely changed by experience.

4. Some of the responses in our list above are not attended by consciousness, whereas others are accompanied by a high degree of consciousness. Once more the pupillary reflex offers the best example of the former, since we are not even conscious afterwards that the response has occurred. In other cases we are conscious of the responses after they are made, but consciousness plays no part in the responses. This statement is true of sneezing and hiccoughing, for example. In still other cases, the higher brain levels function in the responses, and consciousness is present during the responses, as for example in many play activities or in fighting.

5. Finally, some of the responses listed above are very definite and specific in character and are made only to very narrowly prescribed situations, while others in the list are rather general in character and may be made to a wide

variety of situations. Sneezing, for instance, is always very much the same response and is made only to a situation which may be described as "the presence of substances that irritate the mucous lining of the nasal passages." Imitating the acts of others, in contrast, may include a variety of responses and may occur in response to a large number of situations. We may express this difference in native responses by saying that they vary in definiteness.

We may say, then, that native responses, and hence the neural connections upon which they depend—that is, the native controls of conduct—vary widely with respect to (1) the time of their appearance, (2) their complexity, (3) their modifiability, (4) the degree of consciousness attending them, and (5) their definiteness. The first of these five differences is not so serviceable in attempting a classification of native controls as are the remaining four. Considering only the last four differences, we may say that native controls of conduct vary from those that are, relatively speaking, simple, unmodifiable, unattended by consciousness and definite to those that are highly complex, readily modifiable, attended by a high degree of consciousness[1] and very indefinite. While there is some tendency for controls to appear in the organism in an order corresponding to their complexity, modifiability, degree of attending consciousness and definiteness, this relationship is not at all perfect.

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[1] This statement should not be interpreted to mean that these four characteristics of controls vary strictly *pari passu*. If, for example, A, B, C, D, E denote a series of controls arranged in an increasing order of complexity, it does not follow that the same order would be obtained if the controls were arranged in the order of their increasing modifiability and again in the order of increasing degree of attendant consciousness and finally in the order of their increasing indefiniteness.

**Classification of native controls.**—A universally accepted classification of native controls of conduct has not yet been made. For the purpose of understanding their functioning in human behavior, and particularly in learning, it seems that we can do no better than to accept Thorndike's[1] threefold classification under the headings of (1) reflexes, (2) instincts, and (3) capacities.

These three classes of controls are not sharply separable from one another and no attempt will be made to define them rigidly. Reflex responses are, relatively speaking, characterized by simplicity, unmodifiability, lack of consciousness involved in them (though the individual may be conscious of some of them after they are performed), and definiteness. Instinctive responses, typically, differ from reflex acts in being more complex, more modifiable, marked to a higher degree by attendant consciousness, and more indefinite. No sharp line of demarcation can be drawn between the two classes, however, nor can one specify just how great a measure of complexity, modifiability, attendant consciousness, and indefiniteness must be present in order that the response be definitely classifiable as an instinctive act rather than a reflex act. Finally, as we progress in our consideration of various controls further and further away from typical instincts and in the opposite direction from reflexes, we encounter controls that function in very wide ranges of situations to produce widely different particular responses. Furthermore, these controls, generally speaking, depend in a large degree upon training for their effectiveness in determining behavior. Perhaps they should be thought of as conditions of readiness to form neural connections rather than as actually formed connections. These we call capacities, or tendencies to respond in conformity to a general pattern or mode.

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[1] THORNDIKE, E. L.—*Educational Psychology*, Vol. I. New York: Teachers College, Columbia University, 1913, p. 5.

1. *Reflexes.*—We have had occasion frequently to refer to the nature of reflex acts and little more need be said of them here. It should be clear to the reader that these responses depend upon one or more synaptic connections provided by nature and, for the most part, ready to function almost from birth. Since we are using the term reflexes to denote one group of native controls, we should understand it to mean the neural organization, while the resulting response is known as a reflex act.

The number of responses that may be classified as reflex acts is larger than the reader may be inclined to think from the limited number of illustrations we have given thus far at various points in this volume. Warren[1] lists some sixty-seven responses which he regards as reflex acts, and some of these are groups of allied responses rather than single responses. The following are among the reflex responses in Warren's list: snoring, shuddering, trembling, sneezing, yawning, tickle reflexes, breathing changes, groaning, laughing, coughing, swallowing, weeping, smiling, scowling, hunger and thirst reflexes, vocal reflexes, grasping, clasping, reaching, jumping, sitting, and equilibration.

2. *Instincts.*—We have said that there is no sharp line of demarcation between reflexes and instincts, but that the latter as a group differ from the former in being more complex, more modifiable by experience, attended by a higher degree of consciousness, and more indefinite. It is also true that a reflex response is of brief duration, whereas an instinctive activity may extend over a considerable period of time, as for example in the case of nest-building by a bird.

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[1] Warren, H. C.—*Human Psychology.* Boston: Houghton Mifflin Company, 1919, p. 101.

An interesting illustration of instinctive behavior in the lower animals is supplied by Fabre's description of the solitary wasp, *ammophila*, which preys upon a certain caterpillar. The female wasp seizes the caterpillar and plunges her sting into the nerve ganglia so that she paralyzes the caterpillar's organs of locomotion but does not kill it. She then carries or drags the caterpillar to her nest and lays her egg upon it, sealing up the nest and thus leaving a supply of fresh meat for the grub which will hatch from the egg.

Now the behavior of the wasp is clearly due to inborn controls of conduct. She has never seen a similar process carried through by another wasp nor is she conscious of the purpose of the process. But there comes a time in her life history when certain stimuli set the chain of activity in motion and each act in the series serves as the stimulus to its successor.

The instinctive behavior of the human being is in general more modifiable than much of the instinctive behavior of the lower animals, though the latter is in many cases greatly changed by experience. It is probable that the nest-building of birds shows no essential modification through repetition, but not all of animal behavior is so rigid and fixed. Many wild animals, for example, can be tamed by proper treatment so that their responses to human beings are greatly changed. Some of the child's instinctive behavior is modified relatively little by experience and some of it is very greatly changed. Walking, for example, seems to be a type of instinctive behavior which appears usually during the earlier half of the second year of life when the bones and muscles have become strong enough to render it possible. Although it is modified somewhat in its details, it remains essentially the same type of response to the same sort of situations. On the other hand, certain responses commonly known as fighting and anger are also instinctive but they are extensively modified by experience, both as to the particular situations which evoke them and as to the exact nature of the responses made.

If the infant is restrained, has his head held rigidly in one position, or has his hands held, he will probably struggle, cry, show a flushed face, and altogether show a collection of symptoms which may be interpreted as denoting anger and fighting. Five years later, this infant, now a boy, responds to certain situations in a way that we call fighting, but the observable characteristics of his behavior will not be the same as those he exhibited as an infant. Let another ten years go by, and the adolescent boy restrains many of the symptoms which the infant displayed but we say that he is still fighting. In doing this we assume that there are common elements or feelings connected with the end or purpose which justify classifying the skillful boxing of the youth with the apparently purposeless writhings of the babe. In another ten or twenty years the boy, now a man, may be fighting to make his way to the head of his profession, or he may be fighting to keep his business from bankruptcy during a critical period, or under a sudden attack of a severe illness he may be fighting for his life. In all of these uses of the term "fighting" we reflect recognition of the same or similar goals. The similarity of these goals may be only that of similitude of a victory over obstacles. The responses of the infant were unlearned or only slightly modified by experience, but later in life the responses to opposition of various kinds are clearly modified by experience.

An entirely satisfactory description of instinctive behavior is impossible in our present stage of knowledge. Such a description would include a precise statement of all the situations to which the individual makes unlearned responses, and also a description of the response made in each case. If such a list of situations and responses could be drawn up, it would be a rather lengthy one. Authorities differ in their attempts to group or classify instinctive behavior for convenience in treatment. McDougall[1] employs seven headings—namely, (1) flight, (2) repulsion, (3) curiosity, (4) pugnacity, (5) self-abasement, (6) self-assertion, and (7) the parental instinct—to denote the true or primary instincts, and adds reproduction, gregariousness, acquisition, and construction as secondary instincts. Warren[2] enumerates more than thirty, and Thorndike[3] more than forty types of instinctive behavior.

We need not, for our purposes, list here all the types of instinctive reactions that appear to constitute a part of man's original nature. Many of them—as, for example, eating, walking, hunting, mating, maternal behavior, fighting and anger, envy and jealousy—are not particularly important in the immediate work of the school. Others—for example, rivalry, curiosity, coöperation, approval and disapproval, imitation, manipulation, and play—appear to be more closely connected with the school training of children. It is doubtful, however, whether a detailed consideration of them would yield any great measure of assistance to teachers in carrying on the actual processes of instruction.

We may conclude by saying that the child is equipped with a great number of native tendencies toward responses to a wide range of situations; that these tendencies are, in general, readily modified in many respects, with the result that purely instinctive reactions are replaced by responses in which experience is an important factor; and that some of these tendencies are desirable and worthy of strengthening, while others should be greatly modified or even suppressed.

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[1] McDougall, William.—*An Introduction to Social Psychology.* Boston: J. W. Luce and Company, 1926, Chapter III.

[2] Warren, H. C., *op. cit.*, p. 106.

[3] Thorndike, *op. cit.* Chapters V to XI.

3. *Capacities.*—One very important characteristic of man's original nature is its capacity for being changed or modified by experience. We refer to this capacity for change when we say that the human infant excels all other animals in plasticity. In other words, the child is subject to far greater modification of its native responses, generally speaking, and is far more capable of acquiring modes of response not provided by nature, than is the young of any other animal.

It appears, however, that the ease and facility with which native responses are modified and new ones are acquired is not a constant trait among children. That is to say, some appear to possess a greater innate capacity for acquiring new responses than others. This is what we mean by saying that some children learn faster than others. Not only does this apply to learning in general, but it is also true, it appears, in the case of particular lines of endeavor. Thus we speak of one person's native aptitude or capacity for music, another's for mathematics, another's for drawing, and so on.[1]

We shall have occasion in later chapters[2] to consider individual differences in capacities and the extent to which capacities are native in character. Whatever the truth may be with regard to these questions, the nervous system does possess some degree of readiness for forming new synaptic connections and taking on new patterns of neural organization, which then function as controls of conduct. Hence, capacities cannot be left out of the inventory of man's native controls of conduct.

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[1] Some such view as that presented here is rather generally, but not universally, held. For a statement of an opposed view, see WATSON, J. B.—"What the Nursery Has to Say About Instincts," *Pedagogical Seminary* and *The Journal of Genetic Psychology*, 32:293–327, June, 1925.

[2] See Chapters VIII and X.

**Concepts of the general nature of acquired controls of conduct.**—Psychologists have proposed a number of theories in regard to the nature of acquired determinants of behavior or controls of conduct. At one time most psychologists held that the mind consisted of a number of faculties—observation (perception), discrimination, memory, imagination, judgment, reasoning, and the like. This theory, which may be traced back to Greek philosophers, was generally accepted until about 1900, but agreement was lacking in regard to the number of faculties. Usually not more than five or six were enumerated in pedagogical discussions but some phrenologists claimed a larger number, in one case as many as forty-three. A faculty was a general control of conduct. For example, if a person's faculty of memory had been trained, he was then equipped to memorize easily all kinds of things—poetry, dates in history, formulæ in physics, vocabulary in Latin, etc. If his faculty of reasoning had been developed, he was then equipped to think reflectively about all sorts of questions.[1]

Beginning about 1890 the psychological theory proposed earlier by Herbart in Germany was introduced into the United States through the writings of Charles De Garmo, Charles McMurry, Frank McMurry, and others. Herbart advanced the hypothesis that the outcomes of learning, and hence the acquired controls of conduct, were ideas or knowledge. "In the place of this [faculty psychology], Herbart substituted the conception that the soul is a unity, not endowed with intuitive or inborn faculties, but a blank at birth, possessing but one power—that of entering into relation with its environment through the nervous system. . . . Through the expansion of the one original power the teacher has to develop *knowledge* from experiences and sympathy from intercourse (contact with society)."[1] The Herbartian theory of controls of conduct is implied in the expression, "Knowledge is power."

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[1] A concept of the learning process, usually called the doctrine of formal discipline, was closely connected with faculty psychology. According to this theory of learning a mental faculty could be developed by means of a formal course of training or mental calisthenics.

A third concept of controls of conduct is represented by Thorndike's S→R bond theory. According to this hypothesis an acquired control of conduct consists of a bond or connection[2] between a situation or stimulus (S) and a particular response (R). According to Thorndike the number of S→R bonds acquired by an adult is very great. "There are millions of them. . . . A volume could well be written showing in detail just what bonds certain exercises in arithmetic, spelling, German, philosophy, and the like, certain customs and laws, certain moral and religious teaching, and certain occupations and amusements, tend to form in men of given original natures."[1] In certain respects this concept of controls of conduct is the opposite of that represented by faculty psychology. According to the latter, the controls of conduct were a few trained faculties; according to Thorndike's S→R bond theory, the controls of conduct consist of several millions of connections each one of which is a bond between a particular situation or stimulus and a particular response to it.[2]

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[1] Monroe, Paul.—*A Textbook in the History of Education.* New York: The Macmillan Company, 1905, pp. 626–27. (By permission of The Macmillan Company.)

[2] There is, of course, no actual physical or material "connection" or "bond" between a stimulus and a response. As we have defined the terms for our purposes, a stimulus is a form of energy external to the nervous system, and a response is the total reaction in the organism, beginning in the receptor and ending in effectors, as the result of the action of a stimulus. But the character of this reaction, we have assumed, is dependent upon neural connections that determine the course of the nerve impulses aroused in the receptors. Hence, when we speak of a "tendency toward a particular response" or a "connection between a stimulus and a response" or an "S→R bond," we mean the neural conditions, the system of synaptic connections, the pattern of neural organization, which determines the response made to the stimulus or situation.

**An eclectic theory of acquired controls of conduct.**—The present writers believe that all kinds of acquired controls of conduct may be described in terms of stimulus-response connections or bonds which may be represented by the symbol S→R. In this statement "response" includes all of the types described in the preceding chapter. By recognizing all types of responses and by introducing certain other modifications,[3] it appears possible to provide a satisfactory basis for explaining the various types of controls of conduct that human beings acquire. Consequently this theory differs in significant respects from that proposed by Thorndike.

This eclectic theory is in agreement with certain well-established beliefs. It is obvious that specific habits or fixed controls of conduct may be described in terms of S→R bonds as Thorndike has proposed. For example, if a pupil who has learned the multiplication combinations is asked, What is the product of 8 times 9? he responds promptly and without conscious effort, 72. The control that led to this response may be described in terms of an S→R bond between the question and 72. Faculty psychology is not accepted to-day, but there is a conviction that the controls of conduct acquired by human beings include some that possess many of the qualities formerly accredited to the faculties of the mind. For example, some persons are recognized as good thinkers. In other words, they are credited with possessing a control of conduct or a group of controls not possessed by the average person, and the belief is that it has been acquired, at least in part. Other traits of a similar type are implied in such words as honest, scientific, open-minded, prejudiced, scholarly, and the like.

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[1] Thorndike, E. L.—*Educational Psychology, Briefer Course.* New York: Teachers College, Columbia University, 1914, pp. 173–74. (By permission.)

[2] It is perhaps not fair to Thorndike to say that he conceives of the controls of conduct entirely in terms of specific S→R bonds. In some places he uses terms that imply the opposite but his S→R bond theory stands out so prominently in his own writing and has been so much emphasized by his followers that his influence upon our thinking about controls of conduct has been much the same as it would have been if his hypothesis had limited the controls of conduct to specific S→R bonds.

[3] These are described in the following pages.

There is also a conviction that knowledge is a powerful determinant of behavior. It seems clear that a person who is not informed cannot thoughtfully respond to problem situations. For example, if the reader of this text had been asked at the beginning of this chapter to compare faculty psychology with the Herbartian theory of controls of conduct, he would have been unable to respond except by guessing unless he had learned about these theories elsewhere. Similarly, in planning a building an architect needs to know a large number of facts; in diagnosing the condition of a patient the physician's response is controlled in part by his knowledge. Hence it appears necessary to recognize acquired controls of conduct that resemble those advocated by the Herbartians.

**A classification of acquired controls of conduct.**—In describing acquired controls of conduct, psychologists use a variety of terms to designate types or classes: habits, motor skills, percepts, ideas, concepts, generalizations, associations, ideals, attitudes, dispositions, and the like. The present writers propose a classification of three rubrics: I. Specific habits; II. Knowledge; III. General patterns of conduct. In proposing this classification they do not mean to imply that there are sharp lines of demarcation between the three groups, or that there are not certain common characteristics. Furthermore, the reader should keep in mind the nature of the neural basis of controls of conduct.[1] In terms of this basis, any control of conduct—specific habit, knowledge or general pattern of conduct—may be said to consist of a neural pathway which functions as an S→R bond, but, as will be shown in the following pages, stimulus-response connections differ in certain significant respects.

**I. Specific habits.**—The functioning of specific habits[2] is illustrated in skillful performances such as operating a typewriter, playing a piano, speaking words and sentences, or driving an automobile. In each of these activities the response is determined by a group of specific habits, each one of which may be thought of as a connection between a stimulus and a response, S→R. For example, in typewriting the striking of a key is a response to a stimulus. In typing a word, a series of responses are made, each one of which is connected with a stimulus.

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[1] See page 114.

[2] The reader should note that the writers are using the term "specific habit" rather than merely "habit." The latter term frequently is used to designate a control of conduct which is here classified as a general pattern of conduct. See pages 138f.

A significant characteristic of this type of S→R bonds is that each one is firmly established, that is, the neural pathway is such that a nerve impulse originating in a receptor travels certainly and without effective resistance to a certain effector. In this respect the control is similar to that which produces a reflex response. Specific habits vary in strength or degree of fixation, but the significant characteristic is the connection between a particular receptor and a particular effector.

Mental responses are also connected with stimuli by bonds of the type designated as specific habits. For example, when a child has learned to do column addition, the partial sums represent mental responses[1] as he adds a column of figures. As the reader of this page looks at the words and phrases on it, certain mental responses are made to these stimuli. If the connection or bond between the stimulus and response is strong enough to be called a *fixed association*, the control of conduct qualifies as a specific habit. Thus "memorized facts" are included under specific habits.

A distinguishing characteristic of specific habits is that the functioning involves relatively little attention and effort. Frequently their functioning is described as automatic or mechanical. These descriptive terms indicate that the bond between the stimulus and response is so firmly established or fixed that a particular response is made immediately and without exception whenever the stimulus is operative, and in general this response is made to no other stimulus. The reader, however, should bear in mind that all bonds between responses and stimuli are not equally strong. Some are relatively weak; others are very strong. Furthermore, there is no authoritative specification of the degree of strength required in order for the bond to be classed as a specific habit. A very weak bond would not be included, but within the class of controls of conduct called specific habits there is a wide range of variation in the strength of the bond.

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[1] The behaviorists believe there are also sub-vocal responses. See page 75.

Specific motor habits frequently are organized into complex series. For example, in driving a golf ball, a number of muscular movements are made. After the series is initiated at the beginning of the backward swing of the club, the stimuli for the successive movements are supplied by the preceding ones or by the positions assumed by the player.[1] In order that the drive may be long and straight, the functioning of the series of S→R connections must be properly synchronized or "timed."

**II. Knowledge.**—Knowledge functions as a control of mental activity, that is, the knowledge a person possesses is a potent factor in determining the ideational content of his mind at any given time and especially in determining the conclusions resulting from his thought processes. Evidence of knowledge functioning as a control of conduct is afforded by thoughtful responses to difficulties, perplexing situations, problems, and the like. In such cases the stimulus is complex, consisting of several elements. If the situation is not entirely "new" some of them will arouse a knowledge response, that is, certain ideas will appear in the consciousness of the person affected. The ideas that appear in response to a stimulus depend upon the person's knowledge. For example, if engine trouble develops in a motor car, a person who possesses relatively little knowledge relating to internal combustion engines may think of his gasoline supply, spark plugs, and the like.

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[1] There are receptor neurones in the muscles and joints. See page 39.

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A competent mechanic would think of various other things. The difference in the mental responses to the perplexing situation is due largely to the difference in the knowledge possessed by the two persons.

According to our hypothesis an idea appears in a person's consciousness as a response to a stimulus because it is connected with that stimulus, but knowledge S→R connections differ from specific-habit S→R connections in certain respects. In the first place, the typical knowledge response is not a single idea but a series, the first idea appearing to arouse a second, the second a third, and so on. This means that knowledge considered as a control of conduct includes not only the connection between the stimulus and the first idea, but also the connections between the successive ideas. This characteristic of knowledge may be represented by the Figure 12, in which $R_1$ is the first response to S but it in turn leads to $R_2$ and so on through the series, which may be very elaborate. The connections between the ideas are usually relatively weak in comparison with specific-habit S→R connections and

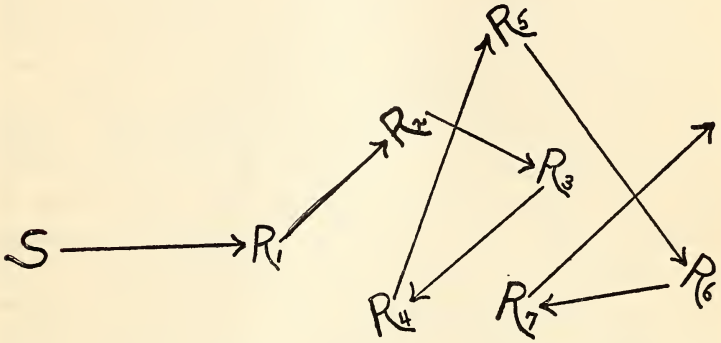

FIGURE 12. DIAGRAMMATIC REPRESENTATION OF A KNOWLEDGE RESPONSE TO A STIMULUS.

consequently the precise nature of the sequence is not fixed. It is influenced by a person's mind-set and similar controls of conduct,[1] and hence may vary on different occasions. Knowledge has been described as an *adaptable* control of conduct in contrast with specific habits which are characterized as *fixed* controls. This adaptable quality is due in part to the connections between ideas which make it possible for the response to be continued until the needed ideas appear.

A second significant characteristic of knowledge is that a given sequence of ideas may be aroused, at least in part, by more than one stimulus. The character of the connections that make this possible is illustrated in Figure 13. $S_1$ is connected with $R_1$, $S_2$ with $R_4$, and $S_3$ with $R_7$. Since the connections between $R_1$ and $R_2$, $R_2$ and $R_3$, $R_3$ and $R_4$, etc., may operate in either direction, any one of the responses $R_1$, $R_4$, or $R_7$ may lead to the arousal of the ideas represented by the other R's. The helpfulness of this characteristic in responding to "new" situations is apparent, especially when we remember that concepts, principles, and rules may be included in the ideational sequence.

This description of knowledge affords an explanation of why a person may recall a given rule in a variety of situations. It also affords a basis for understanding how knowledge functions as an adaptable control of conduct.

The preceding description of knowledge as a control of conduct suggests that the quality of a person's knowledge depends upon the number and strength of connections between ideational elements as well as upon the number of these elements. Specific habits consist of relatively strong S→R connections, a given stimulus being connected with a particular response, and no other. In contrast knowledge is characterized by a multiplicity of connections, especially between its elements. It is often said that knowledge does not consist of a mere accumulation of facts or information. Unless these knowledge elements are organized, there cannot be efficient adaptation to "new" situations. Without effective organization of his ideas, a person will frequently fail to think of the right thing at the right time.

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[1] These are described later. See pages 138f.

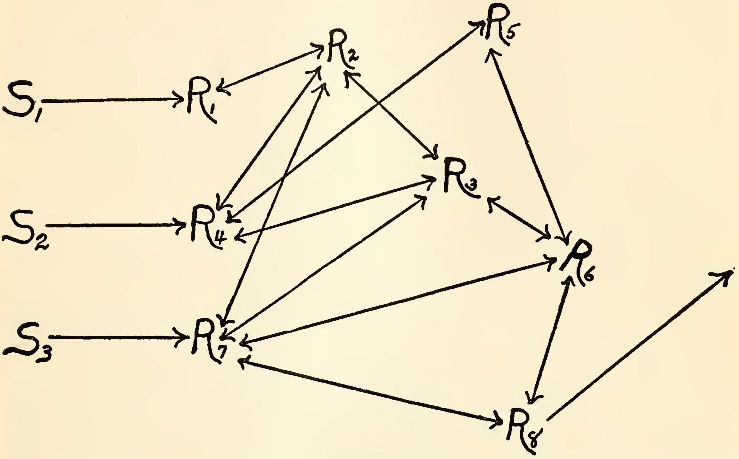

Figure 13. Diagrammatic Representation of the Connection between a Knowledge Response and Several Stimuli.

*Relation of knowledge to reflective thinking.*—Knowledge makes possible reflective thinking. Unless ideas, concepts, principles, and rules are aroused by the stimuli of the problem or perplexing situation, there can be no comparing, reorganizing, synthesizing, and the like. Reflective thinking is not a response that is made apart from knowledge. A person thinks *with* or by means of his ideas, concepts, and other items of knowledge. Hence a person's knowledge controls his reflective thinking in the sense that it to a large extent determines his conclusion.

*How knowledge functions as a control of motor conduct.*— In school we teach facts and principles of physiology and hygiene with the expectation that knowing these things will result in hygienic practices. We teach the rules of English grammar believing that knowledge of these rules will result in correct oral and written language. The fact that a pupil who knows the rules of English grammar frequently does not conform to them in his speech and written work is proof that what we commonly call knowledge does not always function as a control of conduct. Are we mistaken in classifying the ability to repeat and explain a rule as knowledge? Or is there some condition that must be satisfied in order that such an ability be effective as a control of conduct?

The influence of ideas upon conduct is one of the controversial questions of psychology. James believed that ideas were effective controls of conduct. He expressed this belief in the rule: ". . . every representation (idea) of a movement awakens in some degree the actual movement which is its object; and awakens it in a maximal degree whenever it is not kept from doing so by an antagonistic representation presented simultaneously to the mind."[1] In contrast to this position Thorndike asserts that "the idea of a movement (or of any response whatever) is, in and of itself, unable to produce it. I contend that an idea does not tend to provoke the act which it *is an idea of*, but only that which it *connects with as a result of the laws of instinct, exercise and effect.*"[2] This statement admits that knowledge may function as a control of conduct but it asserts that it does this only when a connection has been established between the idea or group of ideas and the response which it defines. For example, knowledge of the rule that the subject and predicate of a sentence should agree in number will function as an effective control of conduct only when there is an established connection between the act of formulating sentences and this rule so that it will appear in consciousness when a sentence is being formulated, especially one that is not familiar.

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[1] James, William.—*The Principles of Psychology*, Volume II. New York: Henry Holt and Company, 1890, p. 526.

[2] Thorndike, E. L.—*Educational Psychology*, Vol. I. New York: Teachers College, Columbia University, 1913, p. 177. The laws of exercise and effect are described on pages 188f. of this text.

Thorndike's position seems to be a defensible one. As pointed out in an earlier paragraph, casual observation is sufficient to convince one that the acquisition of knowledge in the sense that statements can be repeated when called for or even explanations can be given in response to specific questions is no guarantee that the knowledge will function as a control of conduct on occasions when it might be applied. On the other hand, there is sufficient evidence to justify the belief that knowledge may function as a control of conduct.[1] Ideas acquired by reading may control motor responses. For example, the idea that in hitting a golf ball the player should keep his head down may be acquired from the study of a book on golf and if acquired it *may* function as a control of conduct when the reader next goes to the course. Whether it does or not depends upon certain conditions. First, the player must have learned the keeping-the-head-down response, that is, he must have made it to some stimulus. Second, a connection must be established between the idea of keeping the head down and the response. If these conditions are satisfied and the player takes his stance with the idea in mind, he will not raise his head, provided a stimulus to which the looking-up response is connected is not operative. If it is operative, the relative strength of the two stimuli and their respective connections determine the response.

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[1] For a summary of the experimental evidence see Symonds, P. M.—*The Nature of Conduct.* New York: The Macmillan Company, 1928, p. 126f.

**III. General patterns of conduct.**—A very large proportion of our daily activities are controlled by specific habits and some are determined by knowledge, but it is apparent that another type of controls is operative. We use such words as truthfulness, dependability, studiousness, honesty, frugality, kindliness, obedience, and loyalty to designate controls that are generally recognized as powerful determinants of conduct. Truthfulness, for example, operates to make a person's statements and other modes of expression accord with his observations, beliefs, and understanding of the situation. The functioning of this control of conduct tends to be fluent and without deliberation. In fact, it is frequently called a habit or general habit, but it differs from a specific habit in that it is a mode or pattern of response rather than a definite response to a particular stimulus or situation. The truthfulness response is made to a variety of situations and if sufficiently generalized it may be made to all situations involving verbal statements or other modes of expression. The stimulus-response connection is between some element or group of elements common to such situations and a mode of response which may be described as comparing a contemplated statement or other expression with one's observations, beliefs, and interpretation of the situation. If a connection has been established between an element or a group of elements common to expression situations and this mode of response, a person will make it habitually. The control of conduct includes another significant phase. If a person is truthful he not only makes the comparison but he experiences dissatisfaction when there is not agreement and derives satisfaction from agreement.

The term "general pattern of conduct" is used here to designate a variety of controls of conduct which are similar to truthfulness. Ideals, attitudes, purposes, tastes, prejudices, and interests are commonly used to designate certain types. In all cases the response is a mode or pattern[1] and the stimulus is an element or group of elements common to a variety of situations. Hence the name, general pattern of conduct.[2] It should be noted, however, that the degree of generalization of the control of conduct, which is represented by the range of situations to which response is made, may vary in different persons and in the same person from time to time. For example, some persons are scrupulously honest in some lines of activity but not in others. The explanation of this is that this ideal of honesty has been generalized only to a limited extent.

Another characteristic of a general pattern of conduct, especially attitudes, purposes, and prejudices, is that when they are once aroused they tend to persist for some time. The functioning of such general patterns is not terminated promptly but may continue for several hours, or days, or even years. For example, a determination to become wealthy may influence a man's conduct for years. A prejudice tends to influence a person's thinking in certain fields throughout his lifetime.

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[1] See pages 100f. for a description of these responses.

[2] The word "habit" is widely used as a name for this class of controls of conduct. For example, Dewey uses it with this meaning in the following statement: "The essence of habit is an acquired predisposition to *ways* or modes of response, not to particular acts except as, under special conditions, these express a way of behaving. Habit means special sensitiveness or accessibility to certain classes of stimuli, standing predilections and aversions, rather than bare recurrence of specific acts. It means will." DEWEY, JOHN.—*Human Nature and Conduct.* New York: Henry Holt and Company, 1922, p. 42. (By permission of Henry Holt and Company.)

*How general patterns control conduct.*—The various situations in which a given general pattern functions include one or more common elements which act as a stimulus. A person who has acquired the general pattern of conduct is sensitive to this stimulus, that is, he has acquired an S→R connection between this stimulus and the pattern of conduct. The response functions as an "inner steer"[1] or directive tendency relative to the specific habit and knowledge responses made to the situation. In some cases the presence of the general pattern operates to strengthen the connection between a stimulus and a specific habit or knowledge response; in other cases it serves to inhibit or modify a response. For example, consider a person who is judicially minded. In such a person, a question or a situation requiring judgment arouses the general pattern that we commonly call a "judicial attitude." When aroused this attitude affects his verbal response to the question. It makes him more deliberate. It prevents him from expressing the answer that comes into his mind without first applying certain tests. It causes him to consider both sides of the question.

The functioning of a general pattern of conduct may be represented by Figure 14. The situation S arouses a pattern response P in addition to the knowledge responses. This pattern may influence the knowledge responses and is almost certain to influence the thought processes Rt. In the words of Woodworth it functions as an "inner steer." In the above illustration attention was called to the fact that the judicial attitude causes a person to consider both sides of the question. This means that the knowledge responses will probably be different because of the presence of this general pattern. Its presence will make the thought processes more deliberative and the judgment may be qualified in certain respects.

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[1] This term is used by Woodworth, R. S.—*Psychology.* New York: Henry Holt and Company, 1921, p. 71.

*The importance of general patterns of conduct.*—The importance of general patterns as controls of conduct is obvious. Specific habit responses can be engendered for stimuli and situations that occur frequently and without significant variation, as in arithmetical calculation or the spelling of familiar words. Knowledge serves as a means for solving problems or responding to other new situations. There is need, however, for controls of conduct in addition to these two classes which will insure, in so far as it is possible to do so, conduct that conforms to the standards which the race has evolved in the course of its existence. Kilpatrick stresses the importance of general patterns of conduct in *Education for a Changing Civilization.* "Our

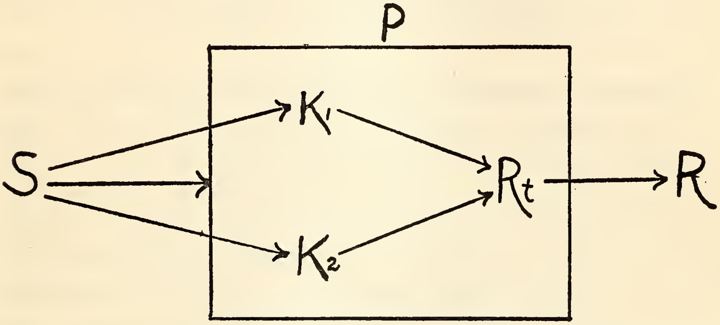

FIGURE 14. DIAGRAMMATIC REPRESENTATION OF THE FUNCTIONING OF A GENERAL PATTERN OF CONDUCT.

new effort must be directed principally toward proper attitudes, points of view, and methods of attack. . . . our young people must build such dynamic outlook, insight, habits, and attitudes as will enable them to hold their course amid change."[1] Another writer points out that our responses to new situations are "seldom determined by thinking or by action that is original. As a result of inheritance and experience, sometimes single but usually multiple, every one develops a large number of more or less generalized attitudes which condition and to a large extent determine all future responses."[2]

**Voluntary control of behavior.**—The preceding discussion probably has suggested to the reader that the child acquires controls of conduct which together with the native determinants make him machine-like in responding to situations. In one sense this is true. What a person does in a given situation is determined by his native determinants of conduct plus the resultants of his experiences. It may not be possible to identify the particular experiences from which the controls of conduct were derived, but in the light of what we know about human responses to stimuli it appears that a person's behavior at any given time is an expression of his native equipment plus the products of his past experience. Dewey says: "In any intelligible sense of the word they (habits)[3] are will. They form our effective desires and they furnish us with our working capacities. They rule our thoughts, determine what shall appear and be strong and which shall pass from light into obscurity."[1]

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[1] Kilpatrick, W. H.—*Education for a Changing Civilization.* New York: The Macmillan Company, 1926, p. 85.

[2] Briggs, T. H.—*Curriculum Problems.* New York: The Macmillan Company, 1926, p. 53. This little volume, especially Chapters II and III, is an excellent reference to read in this connection.

[3] Dewey apparently uses the word "habits" to include *general* habits, or general patterns of conduct, as well as specific habits which he calls "technical abilities."

We, however, frequently speak of behavior in ways that suggest freedom in making choices and in one sense a person is free to make any one of a number of possible responses, that is, free to do as he pleases. We know from personal experience and from the observation of others that frequently a person refrains from making the first response that occurs to him, deliberates considering several possible lines of action, and then decides what he is to do. It is clear enough in one's own experience that the so-called voluntary actions differ from other responses. This difference is due to feelings of effort or conflicts between well-established ways of responding. When the human organism is well started on a series of responses which have been entirely learned, any interruptions of these responses makes the performer keenly conscious of his old adjustment and leads to a distinct feeling of effort as he attempts to meet the interruption. The act of deliberation, however, is not proof that a person's final response is not determined by his past experience. In fact, it is his past experience that makes possible the consideration of the possible responses and their consequences.

A time-honored classification of responses is that of voluntary, involuntary, and non-voluntary. When all psychologists agreed that there was a will which was a special faculty, it was easy to designate a certain conduct as voluntary or arising from the compulsion of the will. It was equally easy to designate mere automatic responses as being non-voluntary. Other responses which had evidently been learned at the expense of some voluntary effort when they became habitual were designated as involuntary. Psychologists, however, no longer think of the will as a faculty. The will as an inner force is no more thinkable than are the instincts conceivable as inner, independent forces. It is true that the belief in the existence of the will made it very easy to place responsibility for behavior. It enabled us to mete out punishment or to seek revenge with a feeling of confidence that is not possible with more mechanistic views of human nature. If we abolish the concept of the will it becomes very difficult to say just when an individual is responsible for his conduct. It may be that his conduct follows a chain of events which were nearly or quite beyond his control.

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[1] Dewey, John.—*Human Nature and Conduct.* New York: Henry Holt and Company, 1922, p. 25. (By permission of Henry Holt and Company.)

**Concluding statement.**—In this chapter we have attempted a description of the controls of conduct and of the ways in which they function in determining the responses made to stimuli. With this description in mind we now turn to the consideration of the learning process, that is, the way in which specific habits, knowledge, and general patterns of conduct are acquired. This topic represents the central problem of educational psychology;[1] the first four chapters of this volume have been essentially introductory.

response [illegible] by make [illegible] pattern of
stimulus grouping elements [illegible] [illegible]
(selection)

## LEARNING EXERCISES FOR THE READER

1. Distinguish between reflexes and instincts.
2. Prepare a description of five general patterns of conduct and of the way in which they function.

traits
purposes
ideals
attitudes
prejudices

general pattern [illegible] [illegible]
some tendency [illegible] [illegible]

---

[1] See page 2.

Represented by a range of patterns tending to [illegible] responses [illegible] – vary in process from time to time

3. What is meant by the degree of generalization of a general pattern of conduct?

4. What "changes" are involved in the acquisition of skill in handwriting?

5. Show that the classification of acquired controls of conduct adopted in this chapter may properly be described as "eclectic."

6. List ten specific habits you possess. Arrange them in order of specificity and generality, placing the most specific first and the most general last. Can you think of another habit that is still more specific than the first in the list? Another that is more general than the tenth? Does it appear that "specific" and "general" are relative terms?

7. Describe two serial responses that may properly be regarded as due to specific habits; also, two that are due to knowledge. How are the first two distinguished from the last two?

8. Why has faculty psychology fallen into disrepute?

9. Contrast the views of James and of Thorndike with respect to the influence of ideas on conduct. Is this an important issue in education? Why?

10. Can you represent the functioning of a general pattern of conduct by means of a figure that differs from Figure 14?

11. What is your conception of "the will"?

12. Comment on the relative importance of the three classes of controls of conduct.

13. Bagley says (*The Educative Process*, p. 122): "If habit, then, is nine tenths of life,—as it certainly is,—the formation of habits should bear a somewhat corresponding ratio to the total task of education." Explain the foregoing statement. Do you agree?

14. Prepare an explanation of the term "control of conduct," having in mind as an audience persons who have not studied educational psychology.

15. What does the term "original nature" mean?

16. Does it seem helpful to describe all types of controls of conduct in terms of S→R connections? Give your reasons.

17. The word "habit" is frequently used carelessly. Examine two of the texts listed on pages 20–21 and determine the meaning of the term as used in each.

18. What is meant by saying that the response which a person makes to a given situation is not a matter of chance?

19. Discuss the following proposition: In the same person the same stimulus will always produce the same response.

20. Illustrate the potency of a mental set as a factor in determining responses.

1. What [illegible] [illegible] [illegible] [illegible] [illegible]
147-187 p.
2. Laws of Learning
3 Learning Process in School activities

In notebook
State laws of learning
definition & examples

# CHAPTER V

## THE LEARNING PROCESS

[illegible] [illegible]
apply them to [illegible]

**The problem of this chapter.**—A human being is so changed by responding to a stimulus that on a future occasion his response to it will be different in some respect from that which would have been given in the absence of the first experience. This idea may be expressed by saying that responding to stimuli tends to modify a human being's equipment of controls of conduct. This process of modifying or changing a person's equipment of controls of conduct is called *learning*. The teacher's task as an instructor is to stimulate and direct responses (learning activities) of such a character that the pupil will acquire those controls of conduct which are specified as the objectives of the school. Consequently the teacher needs to understand the nature of the learning process, especially the laws to which it conforms.

The purpose of this chapter may be expressed in terms of the following questions:

1. What is the nature of the process of acquiring controls of conduct?
2. To what laws does the learning process conform?

**Learning described in terms of initiating and changing the strength of modifiable connections between stimuli and responses.**—The child is equipped by nature so that he makes certain responses to certain stimuli. The equipment that insures this behavior may be designated as native S→R connections.[1] Some of these are modifiable, and the simplest case of learning is the modification of one of these controls of conduct. Two types of modification are possible. A response that is made to stimulus A may be connected with stimulus B, which is designated as a *substitute stimulus*. In the second type, the response is changed by substituting a different one or by effecting some modification of the original response. In either case the new response is designated as a *substitute response*. Hence a modifiable S→R connection may be changed either by substituting a new S or by substituting a new R. Either of these types of changes or combinations of them may be designated as the initial phase of learning.

The second phase of learning relates to changing the strength of an S→R connection which has been initiated. When an S→R connection is first effected it is relatively weak and in order to become an effective control of conduct it must be strengthened. This is accomplished by exercising it, that is, by making the response to the stimulus.

In the learning process the stimulus may be any one of the types suggested on pages 67f. or it may be some combination of these types. The response may be any one of the types described in Chapter III or a combination of two or more of these types. The reader, therefore, should not restrict the meaning of the term S→R connection to a connection between a simple stimulus such as a sound wave and a simple muscular response. The stimulus may be a question, a problem in mathematics, a formula, or a practical difficulty such as engine trouble when driving a motor car; and the response may include perceptions, images, thought processes, a state of attention, and feeling or emotion.

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[1] These were described on pages 117f.

[illegible] [illegible] [illegible]

KΣ

**Learning illustrated by the conditioning of a reflex.**[1]—Connecting a response with a substitute stimulus and a stimulus with a substitute response is illustrated by the conditioning of a reflex. In the Pavlow Experiment,[2] a bell was rung whenever meat was exhibited to a dog used as the subject of experimentation. The odor and sight of the meat constituted the original stimuli. The flowing of saliva was the unconditioned response. There is no natural or native connection between the ringing of a bell and the flowing of saliva, but after the ringing of a bell had accompanied the presentation of meat several times, it was found that saliva would flow in response to the ringing of the bell alone. The salivary reflex in the dog is described as having become *conditioned* or connected with an artificial stimulus. The ringing of the bell is called the conditioned or substitute stimulus. Pavlow varied the experiment by using other stimuli in the place of the ringing bell, and secured similar results.

Rayner and Watson[3] have reported a somewhat similar experiment in which they used a young child as a subject. The child Albert was accustomed to playing with a white rat. Repeated tests showed that he made the fear response only to loud sounds and the removal of support. The experiment involved striking a steel bar, which produced a loud sound, at the instant when Albert reached for the white rat. His response included some of the symptoms of fear and after a few days he exhibited fear when the rat was shown to him. Thus the response made to the sight of the white rat was changed from playing with it (manipulation) to the emotional response of fear. It was found also that Albert made the fear response to other objects of a furry kind. In this case a stimulus was connected with a substitute response.

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[1] For a more complete discussion of this topic see Burnham, W. H.—*The Normal Mind.* New York: D. Appleton and Company, 1924, Chapters III, IV, V, and VI.

[2] For a more complete account see Pavlow I. P.—*Conditioned Reflexes.* Oxford: University Press, 1927. 430 pp.

[3] Rayner, Rosalie, and Watson, J. B.—"Studies in Infant Psychology," *Scientific Monthly,* 13:493–515, December, 1921. See also Watson, J. B.—*Psychology from the Standpoint of a Behaviorist.* Philadelphia: J. B. Lippincott Company, 1924.

In another experiment[1] a child who had learned to make the fear response to furry things was shown a rabbit in a wire cage as he ate his lunch. By placing the rabbit a little nearer day by day he learned to play with it as he ate and his fear responses to furry things disappeared. In this experiment a response that had been learned (conditioned) was unlearned (unconditioned or inhibited).[2]

**The neural basis of conditioning a reflex.**—If our hypothesis in regard to the neural basis of controls of conduct[3] is correct, the conditioning of a reflex involves the modification of one or more synapses so that a neural pathway is formed for the passage of the nerve impulse from the receptor affected by the stimulus to the effectors involved in the response. The precise nature of this modification of synapses and how it is accomplished are not understood, but what occurs produces the effect described on page 115.

**The modification of instincts.**—The conditioning of a reflex has been described as an illustration of learning. Instinctive tendencies may be modified in a similar way. For example, the fighting instinct, which in its unmodified state results in a certain type of response to certain kinds of situations,[1] may be conditioned; that is, the characteristic fighting response may be modified.[2] This instinct may also be modified by connecting the response with a substitute stimulus. For example, we speak of a business man fighting when he encounters difficulties in carrying on his activities. The same description may be applied to the student who attacks vigorously and persistently a difficult assignment. In this case there is a modified response as well as a substitute stimulus.

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[1] Murchison, C. (Editor).—*Psychologies of 1925.* Worcester: Clark University Press, 1927, pp. 64–65.

[2] For reports of other conditioning experiments see Mateer, Florence.—*Child Behavior: A Critical and Experimental Study of Young Children by the Method of Conditioned Reflexes.* Boston: Badger, 1918. 239 pp.

[3] See page 114.

The importance of the modification of instincts as a type of learning is readily seen. If we refer again to the abbreviated list of instinctive reactions given on page 124, we recognize that some of them should be retained and encouraged—at least, within certain limits—and others should be greatly modified, if not wholly eliminated. Thus, eating is obviously necessary, but instinct can hardly be trusted to exercise adequate control with respect to what, when, and how we shall eat. The civilized social order cannot tolerate the anger and fighting behavior to which the unmodified instinct would lead. Curiosity is a very worthy attribute when it is exhibited in some ways and toward some situations, whereas other manifestations of it are not countenanced. Truly, no small portion of learning consists in modifying one's instinctive tendencies toward behavior.

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[1] Thorndike enumerates six kinds of situations: (1) "being interfered with in any bodily movements which the individual is impelled by its own constitution to make, the interference consisting in holding the individual;" (2) encountering a moving obstacle; (3) "being seized, slapped, chased or bitten, the escape-movements having been ineffective or inhibited for any reason;" (4) experiencing sudden pain; (5) "an animal of the same species toward whom one has not taken the attitude of submission and who does not take it toward him;" (6) "the mere presence of a male of the same species during acts of courtship." To these six he adds a possible seventh—"being for some length of time thwarted in any instinctive response by any thing." THORNDIKE, E. L.—*Educational Psychology*, Vol. I. New York: Teachers College, Columbia University, 1913, pp. 68–73.

[2] See page 123.

**Sensori-motor learning or acquiring motor skill.**—This type of learning is somewhat similar to the conditioning of a reflex or the modification of an instinct, but in general it represents a more advanced level of the child's education. Freeman[1] recognizes three types of sensori-motor learning. In the *first*, the learner connects a motor response which he already is accustomed to make with a new stimulus. For example, in sorting cards alphabetically, the placing of a card in a pigeonhole is a movement which the child already "knows." The learning consists in connecting the movements necessary for placing a card in the pigeonhole marked "A" with the sight of words having "A" as the initial letter, the movements necessary for placing a card in the pigeonhole marked "B" with the sight of words having "B" as the initial letter, and so on for the other letters of the alphabet. A similar process is involved in learning to drive a car. The movements required in turning the steering wheel, shifting gears, and operating the brakes are not new. The learner already "knows" them but he must learn to make them in response to new stimuli. In both of these illustrations, the learning consists of connecting a motor response with a substitute stimulus.

In the *second* type a "new" movement is organized and connected with appropriate stimuli. The organization of this "new" movement involves the selection of one or a few of the movements from a group that the learner is able to make. For example, in handwriting, learning to hold the pen involves selecting certain movements from the primitive act of grasping. In addition the selected movements must be combined into a new pattern or series. Learning to pronounce new words or to play games requiring motor skill are other illustrations of this type of sensori-motor learning.

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[1] Freeman, F. N.—*How Children Learn.* Boston: Houghton Mifflin Company, 1917, pp. 128f.

The *third* type listed by Freeman includes the organization of highly complex series of movements such as are found in typewriting or piano playing. The chief part of the learning consists, not primarily in becoming able to make correctly the separate elementary movements, each in response to a peripheral stimulus, but rather in linking the elementary movements together so that they follow readily in proper order, each serving as the cue for the next. The peripheral stimulus merely sets off the series. As repetition of the series goes on, the elementary responses may become woven together into larger and larger units. The typist, for example, does not respond to single letters, but rather to words or even phrases. But such a degree of skill in typing results only from extensive practice in which trial and error must play a part.

**Trial and error in sensori-motor learning.**—"Trial-and-error" learning is commonly used to designate one phase of the process whereby a motor response becomes strongly connected with a peripheral stimulus. When a subject is confronted with a *new* situation, he may respond by making more or less random movements. Those that are satisfying tend to be retained, that is, a connection is initiated between them and the situation, and those that are unsuccessful tend to be eliminated. This type of learning has been studied by using rats and similar animals as subjects. In the maze experiment a hungry animal is placed in an enclosure from which it can reach food by following a more or less complicated path. The maze usually includes blind alleys and numerous opportunities for taking the wrong path. When placed in such an enclosure the animal's responses to the odor of the food are random. Many of them are wrong, i. e., do not bring him closer to the food, but eventually he reaches the food.[1] On subsequent trials the animal gradually eliminates useless movements (entering blind alleys) and eventually learns to follow a direct route to the food. The learning may be described as establishing a connection between a stimulus (the odor of food) and a motor response (the movements involved in reaching it by a direct route).

A more meaningful name for this type of learning would be "trial and success" because the learning takes place in selecting the successful movements and organizing them into a response to the situation. In the beginning the situation functioned as a complex of stimuli to which numerous responses were made. The making of these responses was determined by the animal's equipment of reflexes and instincts together with the non-native controls of conduct it may have acquired. The effect of the responses operated to produce the selection of those that were satisfying and the elimination of those that were not. In this way the animal learned, i. e., acquired a control of conduct.

Although trial-and-error learning is most clearly observable in animals such as rats and cats, it occurs in human beings. In fact, it is involved in learning to play the piano, use the typewriter, drive a golf ball, and the like.[1] For example, the movements of a pupil learning to use a typewriter are not wholly random, but many trial movements are made, especially when several separate movements are being combined in a series. Evidence of trial responses is afforded by the errors made. When the wrong key is struck, the movement is unsatisfactory or annoying. Consequently, the tendency to make it is weakened. On the other hand, the correct responses are satisfying and the S→R connections involved are strengthened. Some of the successes are accidental, especially during the advanced stages of learning. This is probably more apparent in learning to drive a golf ball. Many muscular responses are involved in the series and a fine coördination is necessary in order to secure a long, straight drive. As a learner practices, this result is sometimes secured. Such drives represent successes. Poor drives represent unsatisfactory responses. As the practice continues, there is a gradual selection of those responses that produce the satisfying effect.

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[1] For a specific illustration of the performance of a rat placed in a maze see Woodworth, R. S.—*Psychology.* New York: Henry Holt and Company, 1921, p. 306. See also Sandiford, Peter.—*Educational Psychology.* New York: Longmans, Green and Company, 1928, Chapter X.

**Imitation a means of economy in sensori-motor learning.**—The selection of the desired responses by "trial and error" is dependent upon trials being made which include these responses. The child's native equipment plus what he has already learned may insure adequate trial movements, but obviously the period of trial-and-error learning will be shortened if the first trials approximate the desired responses. Children frequently imitate the actions of adults and other associates. For example, a child sees his mother writing and he wishes to write also. A child who associates with another who stutters frequently begins to stutter also, although he has made no effort to copy the speech of his associate. Thorndike and some other writers recognize an imitative tendency,[1] that is, a tendency of a child to respond to actions of a person he observes by performing these actions. Such a tendency is a potent factor in the initial stages of sensori-motor learning, especially when it is supplemented by a desire to imitate. For example, in learning handwriting, it is not necessary for the child to learn how to hold his pen by the relatively slow trial-and-error process. Instead he may observe the demonstration by his teacher and imitate his manner of grasping the pen.

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[1] For a more complete discussion see Freeman, F. N.—*How Children Learn.* Boston: Houghton Mifflin Company, 1917, pp. 133 f.

The fact that imitation may operate to reduce the amount of trial-and-error learning is suggestive of a somewhat broader principle of teaching. Acts of motor skill always require some amount of trial-and-error learning simply because the act cannot be performed correctly the first time it is attempted. The amount of time and energy expended in trial-and-error practice can often be greatly reduced by helpful direction of the process. If the learner is given a clear explanation of the correct procedure and has the act demonstrated to him until he has the right idea of its performance, he will often learn to do it successfully in much less time than if he is left to his own unguided efforts. Suppose, for example, that one knows that it is possible to throw a baseball in such manner that it will follow a curved course, but has no idea whatever as to how it is held and released in order to cause it to curve. The amount of time such a person would have to practice in order to discover the right procedure would certainly be many times greater than it would be if he were told and shown how to perform the act. In fact, he might never make the discovery unaided, though he might learn to throw a curve in a few minutes if properly directed.

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[1] Thorndike, E. L.—*Educational Psychology*, Vol. I. New York: Teachers College, Columbia University, 1913, Chapter VIII.

**Drill in sensori-motor learning.**—It is apparent from the preceding description of sensori-motor learning that the acquisition of motor skills requires a vast amount of repetition. One does not become an expert in penmanship, singing, playing the piano, typewriting, telegraphy, golf, tennis, juggling, and other performances involving motor skill without faithful application during long periods of practice. In fact, absolute perfection in such activities as those just mentioned is unattainable. The price one must pay for becoming the most skillful performer of his generation is enormous. To maintain this status after it has been attained also requires persistent practice. One is reminded of the story of the famous pianist who, it is said, carried a keyboard of a piano with him when traveling and practiced on it for hours every day while riding on the trains. When asked why he did so, he replied that, if he failed to practice one day, he could detect a difference in his playing; if he neglected practicing for two days, his wife observed the difference; and, if he left off practice for three days, the public noticed the difference.

The sensori-motor learning that occurs in school is not intended, of course, to result in the highest degrees of expertness. Some measure of skill, however, is sought, and this can be attained only through attentive repetitions. Even after satisfactory responses can be made, later repetitions will be necessary to maintain this level of proficiency. Most of the practice, however, is required in forming the connections rather than in preserving them after they are established. In this respect sensori-motor learning differs from associative learning, since in the case of the latter it is possible for the desired responses to be made without any period of trial-and-error learning, but numerous repetitions may be needed to strengthen connections that may have been set up rather readily.

**Perceptual learning.**—In considering perceptual learning, two central questions deserve attention: (1) How does the child learn to perceive? (2) What are the contributions of perception to the child's acquired controls of conduct?

The first of these questions implies that the child must learn to perceive; that is, to make an appropriate meaning response to a given peripheral stimulus or group of stimuli. A baby's perception of his rattle was described on pages 81f. How does he learn to make an appropriate meaning response to the sight of the rattle? The process is somewhat similar to the conditioning of a reflex. To the stimuli involved in handling the rattle, certain responses are made. The visual stimulus is one of the group, and eventually he learns to make to it alone a response that includes images of his experiences in handling the rattle. Similarly the child learns to recognize other objects of his environment. The building of his perceptual world is a gigantic and long-drawn-out task for the child. All his senses—sight, taste, smell, sound, touch, movement, and the rest—coöperate in furnishing him with information about his environment; and out of countless varied patterns of experience emerges the power of giving meanings to the sensations he receives. He comes to recognize objects, to judge distances and directions, to locate the sources of sounds, and so on through a list of accomplishments that are really marvelous. And all the while he is accumulating an enlarged and enriched stock of meanings which he assigns to the objects perceived.

A detailed description of the process of perceptual learning is not essential to our present purpose, but certain points deserve our attention.[1] In the first place it should be emphasized that perceptual responses are learned responses. Evidence of this fact is furnished by comparing the child's and the adult's perceptual responses to an automobile. To the former, it may be "a big object which runs fast and makes a noise." But the adult may glance at the machine and say, "A Speed-demon, 1927 model, 8-cylinder; will make seventy miles, but a hog for gas; heavy upkeep, too; not a good buy at $2800." The difference between these responses is due to the adult having had certain experiences with automobiles which the child has not had. In other words, the difference is due to the difference in their perceptual learning with reference to automobiles.

For the most part, one's perception of a particular object is the result of a multitude of former experiences, each of which effected some change which was so slight, perhaps, that it produced no sense of growth. Yet the final result of all the minute accretions of meaning is often very great, so that the later perception of the object is a very different response from the earlier perception. When we reflect upon the countless perceptual responses in which the adult's meanings far surpass those of the child, and then consider in each case the numerous experiences upon which the richer meanings depend, we can understand in some measure how common, yet how significant, a process perceptual learning is.

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[1] For a more complete account see Freeman, F. N.—*How Children Learn.* Boston: Houghton Mifflin Company, 1917, Chapter IX.

Laboratory evidence of improvement in the perceptual response to a given stimulus is furnished by Judd's[1] experiments with the Müller-Lyer illusion.[2] It is difficult for one to believe without measuring MN and RS in Figure 15 that they are equal in length. In Judd's experiments, the subject, who was not aware of the illusory character of the figure, was asked to place the second card upon the first, as shown in the last part of Figure 15, in such a way as to make the exposed portion of A equal in length

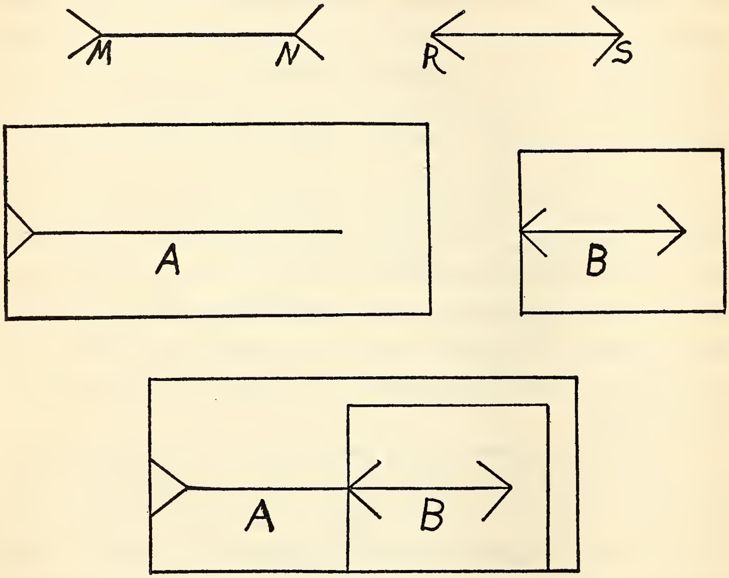

Figure 15. The Müller-Lyer Illusion.

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[1] Judd, C. H.—"Practice and Its Effects on the Perception of Illusions," *Psychological Review*, 9:27–39, January, 1902.

[2] An illusion is a false or erroneous perception. That is, the perception does not correspond to the facts in the environment. Thus, the hunter "sees" a squirrel partly concealed by the foliage and shoots at a knot on the tree; or one hears the drone of an insect and looks up for the airplane that he thinks is soaring above him.

to B. At first the subject made A considerably shorter than B, but was not aware of his error. The experimenter measured and recorded the error and asked the subject to repeat the performance. This was continued for many trials, with the result that the amount of error gradually decreased and finally practically vanished. The decrease in the error, as well as changes in the character of the eye-movements in judging the lengths of the lines, showed that the perceptual process changed with practice, even though the subject was not conscious of the original errors or of the improvement through practice.

The adult's perceptions differ from those of the child not only in the fuller, richer meanings assigned to the sensations, but also in the greater degree of accuracy with which objects are perceived and the finer discriminations made among stimuli. The child's first perceptions of objects are doubtless impressions of them as rather vague wholes. Through repeated later experiences these wholes are analyzed more and more into their elements. Details which were at first unnoticed are later recognized. New qualities and characteristics are discovered. The extent to which the analysis is carried, however, depends in some measure upon the degree in which attentive observation, or purposeful perception, is practiced. The adult may, for example, glance indifferently at a certain building day after day without enriching his perception of it by discovering anything that had hitherto been unnoticed.

Experiments have shown that the range and accuracy of perception can be increased by training.[1] In order that the maximal results shall be obtained most economically, however, more is needed than mere repetition of perceptions. The pupil should be led to observe with different purposes at different times and, in some instances at least, should be taught what he is to perceive. A map, for example, may be to him a rather vague and meaningless whole, and may remain so through a number of purposeless inspections. But if he is led to examine it at one time with the purpose of finding out what he can about the mountains of the country, and again to note the river systems, and at another time to study the coast lines, and so on, his interpretation of the map becomes increasingly more adequate.

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[1] For example, see Cameron, E. H.—*Educational Psychology*, New York: The Century Company, 1927, 218–20. Also, Dallenbach, K. M.—"The Effect of Practice upon Visual Apprehension in School Children," *Journal of Educational Psychology*, 5:321–34, 387–404, June, September, 1914.

We have said that the adult is able to make much finer perceptual discriminations than the child makes. The extent to which slight differences between stimuli may be observed is well illustrated by the feats of wine-tasters. The expert is able to taste numerous samples of wines and tell in each case in what region and in what year the wine was manufactured. While the case of the wine-taster is perhaps somewhat exceptional, the need for fine perceptual discriminations is frequently encountered in life. The musician's ability to distinguish slight differences in pitch, the painter's discrimination among slightly different shades of color, and the architect's keen sense of form and proportion are cases in point. All such cases illustrate the vast difference between the discriminatory powers of the adult and those of the child. It seems that these differences are due, not primarily to increased acuity of the senses in the adult, but rather to increased power of attention to stimuli and increased range and depth of meaning assigned to the stimuli.

This brief exposition of perceptual learning has not included a number of very interesting and difficult questions. For example: How does one come to perceive depth, that is, to see objects as solids with three dimensions? Since the image on the retina is inverted, how do we see objects right-side up? How does one acquire auditory perceptions of distance and direction? How does one learn to judge size and distance of objects? How does one become able to estimate with any degree of accuracy the rate and direction of moving bodies?[1] These and many other perceptual accomplishments are by no means as simple as we are accustomed to think, and the fact that the child makes such remarkable progress toward them during the first year or so of his life would justify the statement that this period is probably marked by a greater degree of development than any later period of the same length.

As a result of his perceptual experiences the child not only learns to perceive more expertly but he also acquires meanings. His meaning for toys, tools, machines, and other articles of his environment grows out of his experiences with them.[2] When a child defines a hammer as something to drive nails with, or a string as something to tie things with, it is apparent that his meaning for these objects has been derived from perceptual experiences.[3]

Examination of typical definitions given by children reveals that muscular activity is prominent in their perceptual experiences. The other sensations contribute, especially seeing, but kinæsthetic sensations resulting from muscular activity make large contributions to the perceptual world the child is building.

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[1] Some of these questions are discussed by GATES, A. I.—*Psychology for Students of Education.* New York: The Macmillan Company, 1923, pp. 300–05.

[2] See pages 158f.

[3] CHARTERS, W. W.—*Methods of Teaching*, Revised and Enlarged Edition. Chicago: Row, Peterson and Company, 1912, p. 35. Illustrations of children's definitions are given.

**Learning by contiguity of responses.**—When two stimuli operate to produce responses that are contiguous in the child's experience these responses may become connected, with the result that on a future occasion the presence of one will arouse the other.[1] For example, the child is shown the printed letter "A," and at the same time it is pronounced. After a number of repetitions, the child will think of the letter "A," that is, form a mental image of it, when he hears it pronounced. In other words, the response, thinking of the letter "A," has become associated with the auditory stimulus.

This type of learning is very prominent, both in school and in life out of school. It explains, for instance, how the child associates a meaning with the appropriate symbol. For example, after two numbers have been multiplied, the pupil is told that the result is called the product. In this way the pupil forms a connection between the meaning—result of multiplying one number by another—and the word product. The result is that when this meaning is thought of, the name product appears in consciousness, and when the word product is heard or seen the meaning will be thought of. This type of learning occurs in the study of a foreign language. When an English word and its foreign equivalent are presented in contiguity, an association or connection is initiated between them. A student of physics connects the phrase Law of Falling Bodies with a formula as the result of contiguous presentation. Ideas also become associated in the same way.

The associations formed between conscious processes represent an important phase of achievement. In the description of knowledge as a control of conduct[1] the point was made that it consists of connected rather than isolated elements. If a person is to think of the right thing at the right time, there must be an elaborate network of connections among the elements.

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[1] See Chapter III, page 85.

**Memorizing.**—Memorizing is that phase of learning in which S→R connections are so strengthened that there is a high degree of certainty that the response will be made whenever the stimulus is present. As the term is commonly used the response is a number, a fact, a date, a name, a formula, a definition, a poem, or other type of verbal statement. Because of the prominent part which memorizing plays in learning, it will be profitable to consider briefly a few conditions upon which its efficiency depends.

1. The effectiveness of repetitions in strengthening connections depends upon the degree of attention accompanying the process. Mere repetition is not sufficient.

2. In memorizing a body of material, most learners, unless instructed to the contrary, will proceed to learn it in parts. It is rather generally held, however, that memorizing by wholes is more economical. The truth of this belief can hardly be said to have been demonstrated for all learners and all types of material.[2] It is probably true for most learners and in the case of most types of material, especially if the learner has been trained in this method. When the material that is being memorized is of great length, it may be wise to separate it into parts, each of

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[1] See pages 132f.

[2] The validity of the principle that it is better to learn by wholes than by parts has been questioned by Pechstein, Reed, and others. See Reed, H. B.—"Part and Whole Methods of Learning," *Journal of Educational Psychology*, 15:107–15, February, 1924.

which is a fairly definite unit, and then memorize each unit by the whole method.

3. It has often been shown that material is memorized much more quickly, and also retained longer, if its meaning is understood than when it is not comprehended. Pupils should, therefore, in so far as it is possible, understand material before they are required to memorize it.

4. As soon as the learner can repeat any portion of the material without reference to the copy, he should do so. This process is technically known as *recall.* The practice of recall results in greater concentration upon the learning and thus reduces the number of repetitions required for memorization. Recall should not be attempted, however, if verbatim memorization is desired, before the material can be repeated accurately, since inaccurate repetition tends to result in the formation of incorrect associations.

5. If the quantity of material is relatively small, it may be learned in less time at one sitting than if the learning is distributed over several sittings, though the distributed learning will be more permanent than the massed learning. If a relatively large amount of material is to be memorized, however, it will require less time if it is distributed over several periods.

6. When possible, the establishment of logical connections among the portions of the material that is being learned will result in the learning being more rapid and later recall being easier. When there are no logical relationships among the items, it may be found profitable to employ the so-called mnemonic device. For example, the titles of the members of the president's cabinet, as well as the order of their succession to the presidency, may be easily recalled by means of the fictitious St. Wapniacl, *S*

suggesting the secretary of state, *T* the secretary of the treasury, *W* the secretary of war, and so on.

**The construction of learning curves.**—A learning curve is a graphical representation of the levels of achievement reached at various stages of training or practice in some function, or type of performance, such as tossing balls, typewriting, adding columns of figures, and the like. It is constructed as follows: Equal distances are marked off from left to right on a horizontal base line, the successive points of division representing equal increments of practice. The amount of practice may be measured in units of time spent or in units of work done.[1] The levels of achievement reached at the various stages of the practice are represented by means of vertical distances above the base line. Ability may be measured in units of work done in a given time, or in units of time required to do a given amount of work, or in terms of the number of errors made in the performance of a given task in which the time is constant or of no significance.

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[1] Strictly speaking, the amounts of practice, whether measured in time units or in work units, will probably not be exactly equal. Practice involves both the exercise of desirable connections and the elimination of useless or harmful connections. It is obvious that equal periods of time at different stages of practice may not—indeed, probably will not—result in exactly the same amount of exercise and inhibition. Thus, for example, fifteen minutes of practice in typewriting after a level of forty words a minute is reached will result in many more repetitions of useful connections and fewer inhibitions of harmful connections than will the same amount of time at the beginning of the period of training. The same argument holds if the amount of practice is measured in the number of words typed. Typing a thousand words will give the beginner more practice, at least in the sense of inhibiting tendencies toward incorrect responses, than the same amount of typing when a relatively high level of proficiency has been attained.

In constructing learning curves, care must be taken to avoid the use of grossly unequal units in measuring amounts of practice. For example, suppose a learner practices shooting at a target each day and continues on each occasion until he misses the mark. The number of shots fired will tend to increase day by day. Hence, if the learning curve is constructed by letting each interval on the base line represent one day's practice, a very erroneous picture of the rate of improvement will be obtained.

**Illustrative learning curves.**—A number of learning curves for various types of performances are presented in Figures 16 to 22. Figure 16[1] shows the improvement made by one learner in telegraphy. The lower curve shows the progress in learning to receive messages, the upper curve in learning to send messages. Ability is measured in terms of the number of letters received or sent in one minute. In Figure 17, the bottom curve represents improvement in receiving letters not making words; the middle curve, words not making sentences; and the top curve, connected discourse. The curves begin with the end of the sixth week of practice and continue to the

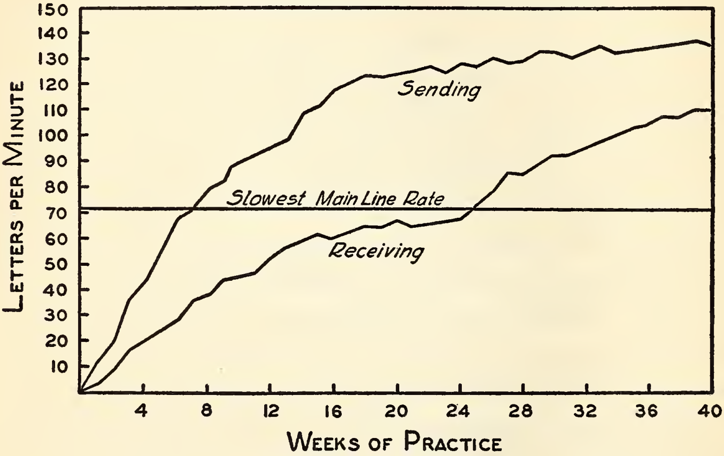

Figure 16. Progress of an Individual in Learning To Send and To Receive Telegraphic Messages. (After Bryan and Harter.)

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[1] Figures 16 and 17 are taken from Bryan, W. L., and Harter, Noble.—"Studies on the Telegraphic Language. The Acquisition of a Hierarchy of Habits," *Psychological Review*, 6:345–75, July, 1899.

end of the thirty-fourth week. Figure 18[1] shows the progress of one subject in learning typewriting. Practice was continued one-half hour each day for 170 days, and ability was measured by the number of strokes in ten minutes.

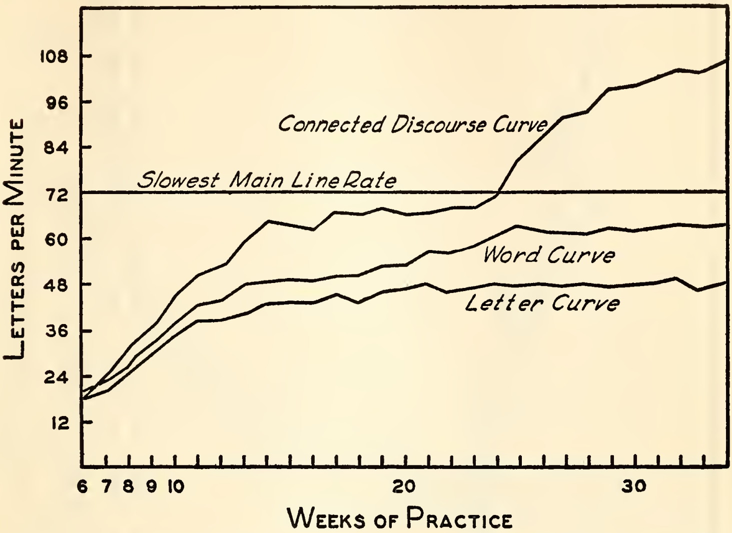

Figure 17. Progress of an Individual in Learning To Receive Three Types of Material.

(1) letters not making words, (2) words not making sentences, and (3) connected discourse. (After Bryan and Harter.)

In Figure 19[2] ability is measured in terms of the number of seconds required in checking, by means of a key, the products written after the eighty-one multiplication com-

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[1] Taken from Book, W. F.—"The Psychology of Skill: With Special Reference to Its Acquisition in Typewriting," *University of Montana Publications in Psychology*, Bulletin No. 53, Psychological Series, No. 1. Missoula: University of Montana, 1908. 188 pp.

[2] Figures 19, 20, 21, and 22 are based upon data obtained by one of the present writers in an unpublished study.

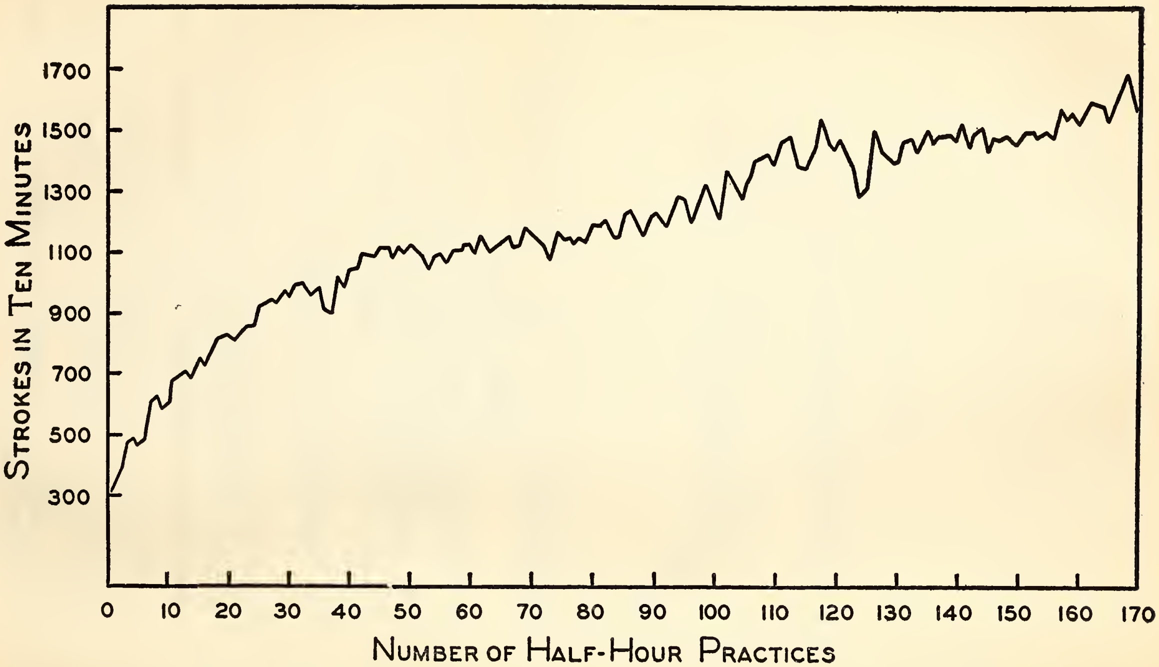

Figure 18. Progress of Individual X in Learning Typewriting. (After Book.)

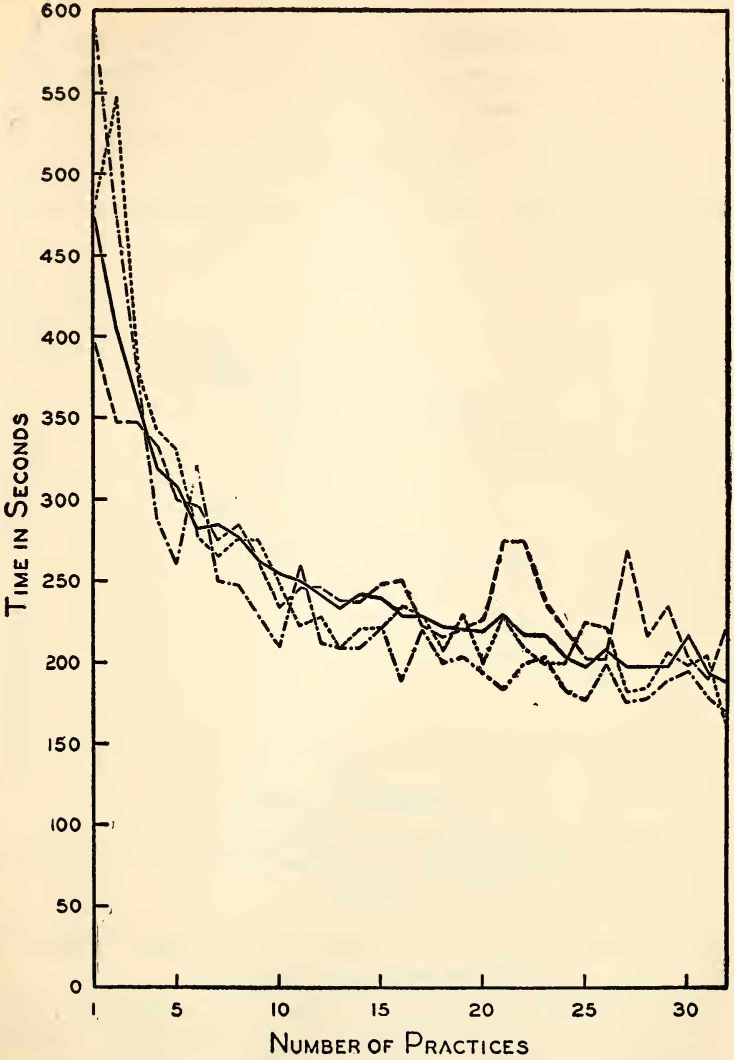

FIGURE 19. IMPROVEMENT IN CHECKING PRODUCTS WITH AID OF A KEY. Solid line, average scores of twenty subjects; dotted lines, scores of individuals.

binations formed by pairing the numbers from 11 to 19. Six forms of the test were used, on each of which one-third of the products were incorrect. These forms differed in the arrangement of the combinations and in the products incorrectly written. The subjects were twenty college juniors and seniors. The solid line represents the average of the twenty scores on each test. A few cases of individual progress are shown by dotted lines.

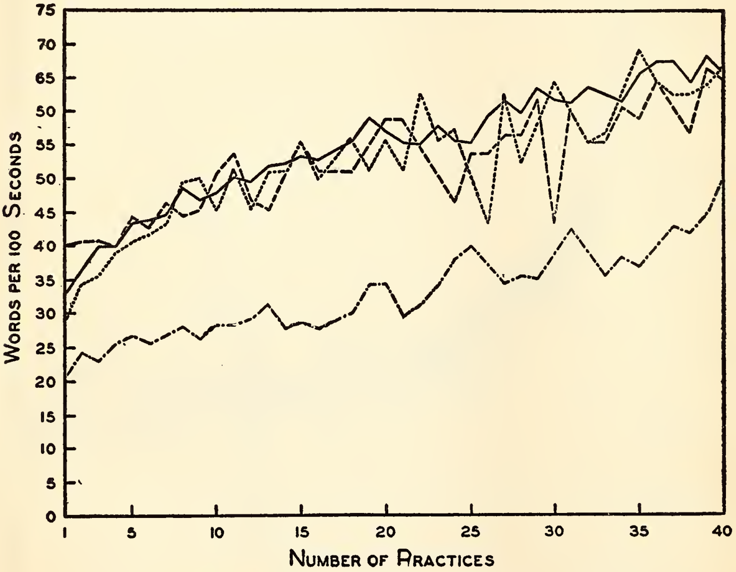

Figure 20. Improvement in Canceling A-T Words.
Solid line, average of twenty-four subjects; dotted lines, individual learners.

The solid line in Figure 20 shows the average of the scores obtained by twenty-four college students in underscoring 100 a-t words on a page of 300 words. The scores are in terms of the number of words correctly underscored in 100 seconds. Six forms of the test were used.

Figure 21 shows the average scores of twenty-nine sixth-grade pupils on tests in classifying names of familiar objects. Each test contained forty names—ten each of animals, birds, flowers, and trees—interspersed among 160

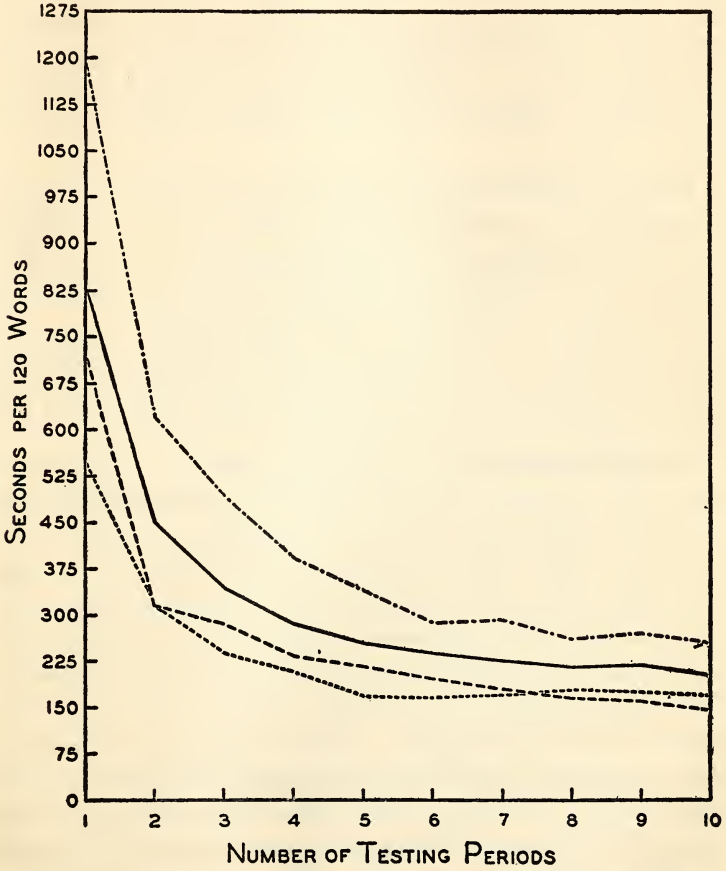

FIGURE 21. IMPROVEMENT IN CLASSIFYING NAMES OF OBJECTS. Solid line, average scores of twenty-nine sixth-grade pupils; dotted lines, scores of individuals.

other common words. These forty words were to be labeled A, B, F, or T according to the class of objects to which each name belonged, the score being the number of seconds required to do the test. Practice was continued for eighteen weeks, one test being given on each school day. At the beginning of the practice, and at the end of each two weeks thereafter, three different forms of the test were given, and the three scores added to obtain measures of efficiency at the various stages of practice.

Figure 22 shows the improvement during eighteen weeks of practice in cancelling A's on a page of printed capitals, each test containing 140 A's interspersed among 700 other letters. The scores shown in Figure 22 are the numbers of A's cancelled in three minutes. The subjects were the same pupils as were mentioned in the preceding paragraph and the testing, as in the previous case, was done at the end of each two weeks of practice.

**Usual characteristics of learning curves.**—Curves which show the progress of learning of an individual through relatively long periods of practice usually, though not invariably, have three common characteristics. In the first place, the curves rise (if ability is measured in work units) or fall (if the scores are in time units) comparatively rapidly at first, and then less rapidly as practice continues. Secondly, the rise or fall, as the case may be, is not consistent and uninterrupted. On the contrary, the curves show frequent upward and downward fluctuations from time to time. Finally, if the minor fluctuations in a segment of the curve are disregarded and its general direction is observed, it is frequently found that the curve follows a horizontal course through a succession of practices. Such a portion of the curve is known as a *plateau* and indicates that no observable improvement is taking place during the portion of the practice represented by it.

Each of these three characteristics deserves a word of comment.

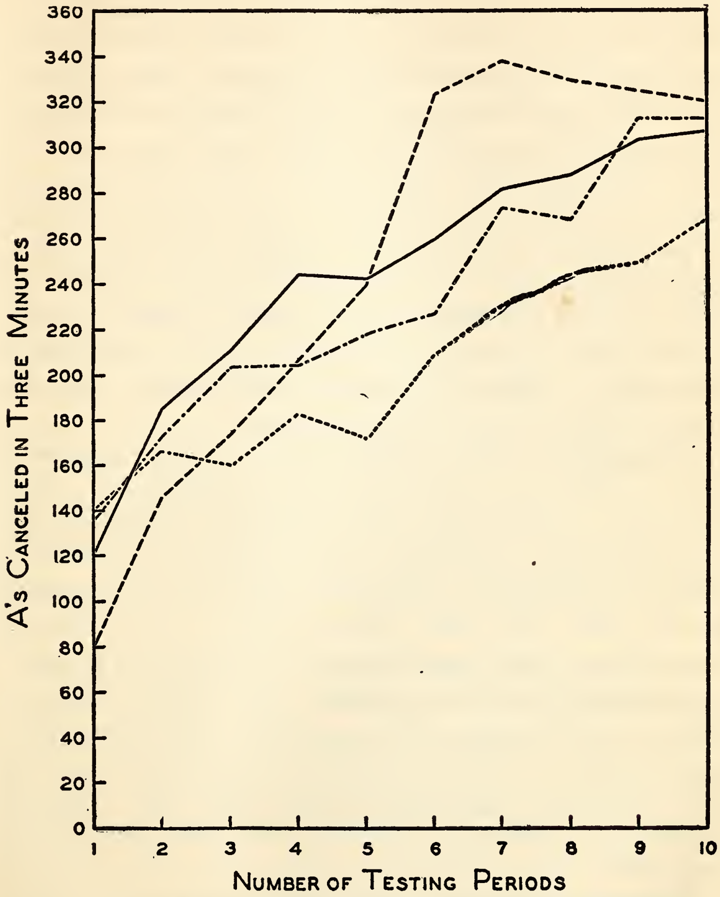

Figure 22. Improvement in Canceling A's.
Solid line, average scores of twenty-nine sixth-grade pupils; dotted lines, scores of individuals.

**Rapid initial improvement.**—The relatively rapid improvement commonly made in the early stages of practice may be due to the joint influence of several factors. (1) Interest and effort are likely to be most pronounced while the task is new, and to recede when the performance begins to lose its novelty. (2) Certain abilities already acquired by the learner may facilitate early progress. (3) The easiest elements in the performance are likely to be mastered first, while those that require more time for their acquisition are learned later. (4) As more and more connections are formed, a larger portion of each practice period is needed in keeping these connections functioning at the levels reached in former practices. In other words, the connections weaken between practice periods, and a part of each practice must be devoted to relearning to offset the amount of forgetting that has occurred since the preceding practice.

**Fluctuations in the learning curve.**—A large number of factors coöperate to determine one's performance at any moment.[1] The learner's degree of interest, desire to make a good showing, confidence in his ability, emotional tone, general physiological conditions, degree of concentration on the task, and other factors influence his manner of responding. Since these factors are variable, it is not to be expected that their combined effect will be constant. Hence, the learning curve is a broken line rather than a smooth curve. This is often true even in the case of the learning curve of a group of subjects, as is shown in Figures 19 and 20. In Figure 21, however, the curve for the group is smooth.

**Plateaus in learning.**—Excellent illustrations of plateaus in learning curves are afforded in Figures 17 and 18.

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[1] These are discussed in the following chapter. See page 220.

The bottom curve in the former figure maintains a horizontal direction from the twentieth practice to the end of the period of training, thus indicating that there was no increase during this time in the learner's ability to receive disconnected letters. The curve for words shows a plateau at about the middle of its course and another at the end, and the curve for connected discourse is marked by a long plateau in its middle stretch. Bryan and Harter advanced the hypothesis that there is a fundamental relationship among these plateaus. They believed that the first plateau in the word curve marked the unavoidable cessation in improvement in ability to receive words until the habits involved in receiving letters were perfected, after which a rise in the word curve was again possible. Similarly, the rise in the curve for connected discourse was halted for a time during which the habits of receiving disconnected words were being thoroughly mechanized. After the word habits were perfected, a rapid increase in efficiency in receiving connected discourse was possible. According to this explanation, plateaus are unavoidable and are not periods of no learning, since very real progress is being made at such times even though the scores do not indicate it.

Two periods of little or no apparent progress are observable in Figure 18. The first extends approximately from the fortieth to the eightieth practice, and the second from the one-hundred-tenth to the one-hundred-fiftieth practice. Book calls these periods "critical stages," since, unless special effort is made to bring about improvement at these levels, the learner may adopt a set of habits corresponding to these degrees of proficiency and find later progress well-nigh impossible. Book does not find such plateaus in the curves of all his subjects, however, and believes they can be avoided if steps are taken to keep the learner's zeal and interest at a high level.

Whether plateaus can be wholly avoided in learning, therefore, is uncertain. It is safe to say, however, that they are more common and more protracted than they need be. They are often the result of a decline in interest and attention or of the adoption of improper habits of performance; their appearance should, therefore, cause both the teacher and the learner to put forth special effort to terminate them.

**The limit of improvement in learning.**—There is, for each person, a theoretical limit to the improvement he can make in many types of performance. Every response involves the passage of a nerve impulse, and, however well organized the neural path over which it moves may be, some time is required for its passage. For example, if a person is instructed to press an electric key as soon as possible after a light is flashed before him, some time elapses between the appearance of the signal and the response. This interval can be measured by means of suitable apparatus and is known as reaction time. It varies with different persons and with the same person under different experimental conditions. In the case of a given individual under a given set of experimental conditions, there is a limit below which training will not reduce the time required for the response.

We may say, then, that there is a physiological limit to the rate at which a given response can be made. In the case of comparatively simple performances—such as repeating the alphabet, typing a single sentence, or repeating a Latin conjugation—this limit of improvement may be reached, or closely approached, with a relatively small amount of practice, provided the learner continually tries to improve. Relatively complex performances, however, are rarely brought to a level of efficiency even closely approaching their limit of improvement. The typist or the telegraph operator, for instance, usually makes no great amount of improvement after becoming sufficiently proficient to secure and hold a position. Improvement ceases not because the limit of improvement has been reached, but because there is no necessity of attaining greater efficiency, or because there is no urgent desire to do so. The performer often feels that the limit of improvement has been reached, and hence halts at a spurious limit instead of progressing toward the true one.

In the case of the acquisition of knowledge, there appears to be no theoretical limit to the improvement that can be made. Having mastered a thousand facts of history, for example, the learner may find the second thousand still easier to acquire, and thus the acquisition of knowledge of the subject may proceed with ever-increasing facility.

**Forgetting.**—Connections between stimuli and responses are weakened by disuse. Some neural connections are made so firmly that they remain strong enough to function over long periods of time; but the greater number of S→R bonds soon become ineffective unless their strength is renewed through exercise. Thus, one learns to-day a street address, a telephone number, a formula, a declension, a stanza of poetry, or what not and often finds to-morrow, or next week, or next year, that it can no longer be recalled. If a particular S→R bond becomes too weak to function as a control of conduct, however, it does not follow that all traces of the connection have disappeared. We may find evidence of the existence of these traces, as well as a meas-

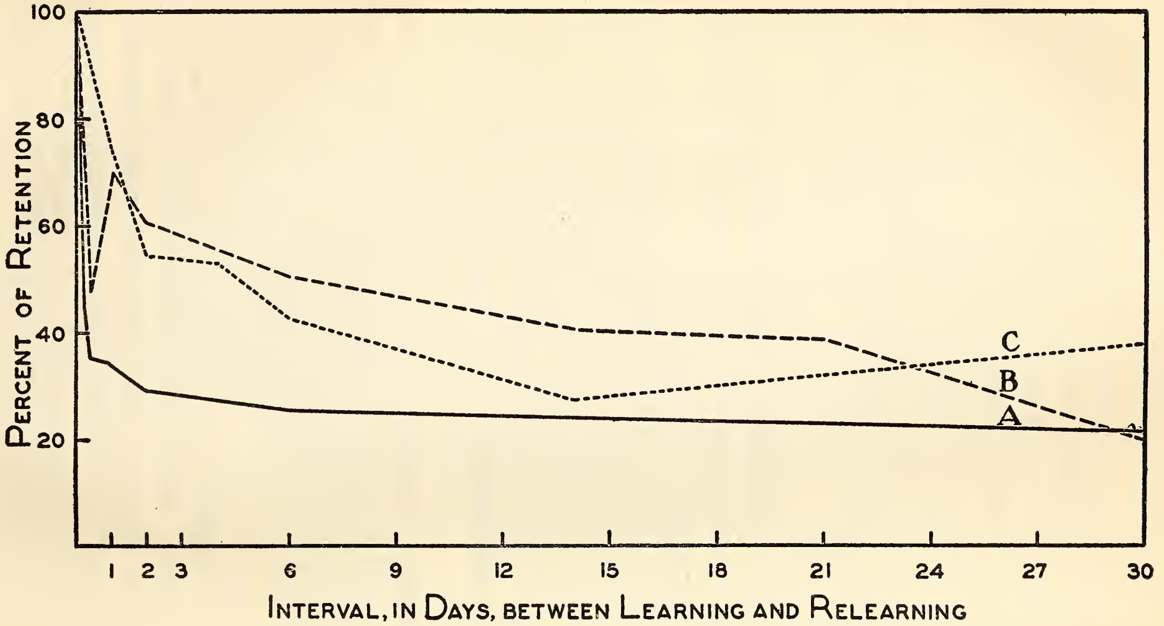

Figure 23. Curves of Forgetting.

A, nonsense syllables (Ebbinghaus); B, nonsense syllables (Radossawljewitsch); C, poetry (Magneff and Radossawljewitsch, combined).

ure of their strength, by comparing the amount of relearning necessary to restore the connection to its former status with the amount of the original learning required in establishing it. This is, indeed, one method that has been employed in determining the amount of forgetting through various intervals.

Experimental evidence concerning the rate and amount of forgetting through disuse is not abundant. The results[1] obtained in a few of the best known studies are shown roughly in Figure 23. Curve A is based upon Ebbinghaus' study of forgetting of nonsense syllables[2] learned to the point of one errorless reproduction. A number of series, each consisting of thirteen syllables, were learned at one sitting. The number of repetitions necessary to learn each series well enough to permit of its being given correctly once was recorded. Then at some later time the same series was relearned, and the number of necessary repetitions was taken as the measure of the amount of forgetting. The difference between the two numbers of repetitions may be taken as the measure of retention. Different series were relearned at various intervals after the first learning, these intervals ranging from twenty minutes up to thirty-one days. Ebbinghaus found that forgetting was very rapid at first, 41.8 per cent. being forgotten in twenty minutes and 55.8 per cent. in one hour. Thereafter, however, the amount changes very slowly, being 78.9 per cent. at the end of thirty-one days.

Radossawljewitsch used both nonsense syllables and poetry in his study of forgetting. The material, however, was learned to the point of two errorless reproductions instead of one.[1] This fact may, in part, account for the difference between his results and those reported by Ebbinghaus. Curve B shows the results only for nonsense syllables. It will be observed that the forgetting was less rapid at first than it was in Ebbinghaus' study, but the amounts at the end of a month were practically the same in the two cases.

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[1] The data upon which the curves of Figure 23 are based are reported in THORNDIKE, E. L.—*Educational Psychology*, Vol. II. New York: Teachers College, Columbia University, 1913, pp. 307–09.

[2] Nonsense syllables are such combinations as *pej*, *kas*, *tuv*, *zob*. That is, each consists of a vowel between two consonants so chosen that no meaningful word is produced.

Magneff used poetry as the material to be learned by his two subjects. His results, roughly combined with those obtained by Radossawljewitsch when poetry was learned, are shown in curve C.

Investigations of retention in such cases of sensori-motor learning as ball-tossing and typewriting reveal a greater amount of retention than in associative learning. Skill declines in such performances, of course, if practice is discontinued, but it is regained relatively quickly if practice is resumed at a later time.

It appears, then, that there is no one curve of forgetting to which all cases will conform. On the contrary, the rate of forgetting appears to be influenced by various factors, such as (1) the nature of the learning (whether sensori-motor or associative, and if the latter, whether the material is meaningful or meaningless); (2) the amount of overlearning; (3) the distribution of the learning; and (4) the learner. Doubtless some persons forget more rapidly than others; but all persons forget meaningless material more rapidly than meaningful material, all retain overlearned material longer than barely learned material, and all retain the effects of distributed practice longer than the effects of massed learning. It seems certain, however, that all curves of forgetting are alike in one respect, namely, that they fall most rapidly at first. This suggests that connections should be exercised at relatively frequent intervals after their original formation and at longer intervals subsequently.

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[1] When repetition is continued beyond the point necessary for immediate errorless reproduction, we may say that overlearning has occurred.

**Learning in problem solving.**—Learning occurs when a person responds to a perplexing situation or difficulty by thinking reflectively.[1] In collecting data pertaining to the problem, items of acquired knowledge are recalled and new knowledge may be obtained by reading or other means. In the recall of acquired knowledge the connections between the elements[2] are exercised and hence are strengthened. In addition, new connections may be initiated as the result of contiguity of the responses. Hence a person's knowledge grows as he uses it. This is an important principle. Knowledge that is not used deteriorates, that is, the connections grow weaker, but when knowledge is used the connections grow stronger and new connections may be formed. The product of reflective thinking is "new" knowledge, and this constitutes one phase of the thinker's learning. The thinker also may learn how to think, that is, he may become aware of the general procedure of the process and the precautions that should be taken. For example, he may learn how to test his hypothesis.

The reader probably has noticed that in the preceding paragraph the statement has been that the thinker *may* learn how to think. This form of statement was employed because it appears that a person who responds to a problem in a way that is accepted as reflective thinking does not always learn how to think. It is likely that this phase of learning occurs only when attention is given to the process of problem solving. If the thinker is interested only in obtaining an answer that agrees with the one given in the text or one that will be accepted by the teacher, he probably learns very little about the process of thinking.

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[1] See pages 92f. for a description of this response.

[2] See pages 132f. for a description of knowledge responses.

**Additional types of learning activities.**—Most writers limit their discussion of learning to the types described in the preceding pages. For example, Freeman[1] lists only the following:

1. Sensori-motor learning
2. Perception
3. Association and memorizing
4. Problem-solving or thinking

These types of learning afford an explanation of the acquisition of specific habits and knowledge, but they do not satisfactorily account for the controls of conduct designated as general patterns[2] in Chapter IV. How do we acquire our prejudices and enthusiasms, our affections and animosities, our moods and our sentiments, our interests and our motives, our ideals and our attitudes? These terms designate controls of conduct which can be described in terms of stimulus-response connections. Those possessed by a given person combine to form those imponderables that are called temperament, personality, and character. These traits are intimately concerned in morality and in citizenship. They may be the conditions of eminence in genius as well as in saintliness.

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[1] FREEMAN, F. N.—*How Children Learn*. Boston: Houghton Mifflin Company, 1917, Chapters VIII to XI.

[2] This rubric has not been recognized by some writers. For example, Pyle asserts that "the results of learning are knowledge and habits." PYLE, W. H.—*The Psychology of Learning*. Baltimore: Warwick and York, Inc., 1921, p. 1.

It is unthinkable that the various types of general patterns of conduct are wholly native and unmodifiable. Emotional and feeling connections seem modifiable to a far greater extent than intelligence.[1] Education's greatest opportunity may be just here. It therefore appears necessary to recognize additional learning activities that will explain the acquisition of general patterns of conduct. If the types of learning activities described in the preceding pages are compared with the list of types of human responses to stimuli on page 78, it will be noted that feeling, emotion, and reaction tendencies have not appeared, except very incidentally. Consequently, we may expect these responses to be prominent in the additional types of learning activity.

The learning activities that produce general patterns are difficult to describe. They are much less definite and tangible than those described in the preceding pages. This is especially true of those activities that lead to political or religious beliefs, prejudices, tastes, and the like. Children exhibit many of the same general patterns of conduct that their parents possess, but it is difficult if not impossible to identify the learning activities from which they are derived. It appears probable that feeling or emotion is involved. For example, on certain occasions the father expresses his political belief, and if he has strong convictions, feeling or perhaps emotion is also evidenced. The child tends to make a similar feeling or emotional response to such situations.[2] Since it meets with parental approval, the tendency to make this response is strengthened. The same learning process is illustrated in becoming loyal to one's school. The student participates in singing college songs, in cheering at football games, in class meetings, and the like. This participation, which involves feeling and frequently emotion, is satisfying to the student and gradually he becomes loyal to his school.

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[1] Intelligence appears to be slightly modifiable. See page 260.

[2] If the reaction tendency commonly designated as the instinct of imitation is recognized, the activity of the child may be described as imitating his father. This, however, merely explains why he engages in the activity and does not describe it.

More than affective activity is involved in acquiring such general patterns. In becoming loyal to his school the student engages in perception, association, and probably other types of learning activity. The thought process called generalizing is frequently involved. The student recognizes that the response pattern called loyalty is applicable to occasions other than athletic events, that is, a connection is initiated between the response pattern and a considerable range of situations in which his school is involved. This phase of his learning may be described by saying that he becomes sensitive to a range of situations.

How does a boy form the purpose of securing a college education? Probably few who have formed this purpose can tell how it was acquired. It may have been suggested by his parents or by some other person. It may have been aroused by reading of the success of college graduates. It may have appeared as a means to some more remote purpose. It is certain, however, that in some way the idea of securing a college education was aroused in the consciousness of the boy, and that it became tinged by feeling. Later it became strongly connected with a stimulus or a variety of stimuli so that the purpose was aroused by a variety of situations.

How does one acquire the ideal of neatness? The learning process probably varies. Charters[1] describes the teaching of this ideal in a particular field. He suggested to a group of stenographers and clerks that the office should be left neat at the end of the day. Their behavior gave evidence of the desire to conform to this suggestion of their superior, but they were unable to secure a satisfactory result until a definite plan of arranging materials and equipment had been worked out. It appears, therefore, that an ideal of neatness is more than merely the desire to be neat. It involves knowing how to be neat. On the other hand, knowing how to be neat is not equivalent to an ideal of neatness. Both phases are essential.

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[1] Charters, W. W.—"Five Factors in the Teaching of Ideals," *Elementary School Journal*, 25:269, December, 1924.

On pages 138f. attention was called to two characteristics of a general pattern of conduct: *first*, a sensitiveness to situations in which the general pattern should function; and *second*, the capacity for a relatively strong affective response to conformity and non-conformity to the pattern, both actual and anticipated. These characteristics must be learned. They are not native. The learning involves the initiation of certain S→R connections and then the exercise of them in order to secure strength.

**Laws of learning.**—Although the preceding description of learning has been organized under a number of types, there is conformity to a small number of laws. There has been occasional reference to some of these laws of learning, but it will be helpful to consider them explicitly and systematically.[1]

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[1] For an elaborate description of the laws of learning in behavioristic terminology see Symonds, P. M.—"Laws of Learning," *Journal of Educational Psychology*, 18:405–13, September, 1927. Twenty-three laws are listed. For other descriptions see Thorndike, E. L.—*Educational Psychology*, Vol. II. New York: Teachers College, Columbia University, 1913. 452 pp. Woodworth, R. S.—*Psychology*. New York: Henry Holt and Company, 1921, Chapter XVI. Gates, A. I.—*Psychology for Students of Education*. New York: The Macmillan Company, 1923, Chapter X.

## LAWS OF LEARNING RELATING TO CHANGES IN THE STRENGTH OF A MODIFIABLE CONNECTION BETWEEN A STIMULUS AND A RESPONSE

Logically the initial formation of a modifiable connection between a stimulus and a response should be considered before the later stages of learning in which the connection is modified, but the approach is simpler if the later stages are considered first. These stages of the learning processes conform to certain laws that may be grouped under three heads: Law of Exercise, Law of Effect, and Law of Readiness. In stating these laws, the outcome of the learning process is designated as a "modifiable connection between a stimulus and a response."[1]

1. **The Law of Exercise.**—The Law of Exercise may be stated formally as follows:

*If other factors affecting learning*[2] *remain unchanged, the strength of a modifiable connection between a situation and a response is strengthened as it is exercised and up to a certain limit the strength of the connection increases with the amount of exercise but not in a constant ratio.*

Closely associated with this Law of Exercise are the following supplementary laws:

*Other conditions being equal, the more recent the exercise of a modifiable connection between a situation and a response, the stronger the connection is. This implies that a connection which is not exercised gradually grows weaker.*

*The strengthening effect of the exercise of a modifiable*

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[1] Thorndike uses this phrase, and a number of other writers have followed his lead. Woodworth uses "linkage of a response to a stimulus."

The outcomes of learning differ in certain respects (see page 128), but for the present purpose it seems unnecessary to make any distinction.

[2] For a description of the factors affecting learning, see page 220.

*connection between a situation and a response depends upon the distribution of the exercise; and, other things being equal, the maximum effect is obtained by distributing rather than by concentrating it.*

Woodworth[1] adds what he calls the Law of Intensity which states that, other things being equal, vigorous exercise strengthens a modifiable connection between a situation and a response more than weak exercise. This appears to be equivalent to saying that, other things being equal, the strengthening effect of exercise is greater when it is accompanied by a state of attention than when the pupil's mental activity is not focalized.

The Law of Exercise is implicit in certain school practices. Teachers are aware that practice is necessary in order to insure that a desired response will be given to a certain stimulus. Consequently, provision is made for drill and review, especially in those fields where specific habits are desired as outcomes. The Law of Exercise is merely a precise statement of a principle that is generally recognized in school practice.

*Connections not always strengthened by exercise.*—Paradoxical as it may seem, exercise under certain conditions does not strengthen a connection. As the result of an experimental inquiry, Thorndike has pointed out that "if a pupil spells reason, 'reason' twelve times out of twenty, 'reson' five times, and 'resun' three times, we cannot expect that mere repetition thereafter will increase the relative frequency of the correct spelling one jot or tittle. So far as its effect is concerned the 60 per cent. for 'reason' will be no larger and the 15 per cent. for 'resun' will be no smaller after ten thousand spellings. The selective force of mere repetition of a situation is zero."[1] It appears that exercise may even weaken a connection. Dunlop has shown that certain undesirable habits may be eliminated by voluntary repetition. He cites nail-biting as an example and prescribes as a cure four periods of practice daily, just before meals and just before going to bed.[2] Whether the exercise of a given modifiable connection strengthens or weakens it is determined by the following Law of Effect.

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[1] WOODWORTH, *op. cit.*, p. 391.

2. **The Law of Effect.**—This law may be stated formally as follows:[3]

*The effect of the exercise of a modifiable connection between a situation and a response depends upon the degree of satisfaction that accompanies or follows the activity. Other conditions being equal, when "a satisfying state of affairs" prevails, the connection is strengthened; when a state of dissatisfaction or annoyance prevails, the connection is weakened.*

This law explains how learning takes place in the "trial-and-error" responses that occur in acquiring motor skill and in thinking. Many responses are made to the situation, and selection is accomplished by means of the accompanying satisfaction and dissatisfaction. It also explains how wrong responses may be eliminated. If the wrong response has become strongly connected with a stimulus, the process of elimination may be slow; but if a "state of dissatisfaction or annoyance" prevails whenever the wrong response is made, the connection will be gradually weakened and eventually become inoperative. The process of "unlearning" or "breaking bad habits" frequently appears to be very slow, and sometimes impossible of accomplishment. In such cases the difficulty is in producing the "state of dissatisfaction or annoyance."

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[1] Thorndike, E. L.—"Curriculum Research," *School and Society*, 28:576, November 10, 1928.

[2] Referred to by Thorndike, *loc. cit.*

[3] Woodworth states this law in the following terms: "The linkage of a response to a stimulus is strengthened when the response is a success, and weakened when the response is a failure." Woodworth, R. S.—*Psychology*. New York: Henry Holt and Company, 1921, p. 392.

A related problem arises in giving verbal instructions to the learner. Is it better to say to the pupil, "Don't do this" or to say "Do this"? As yet there is insufficient experimental evidence on which to base an answer for typical school situations. In a recent laboratory study of learning a particular muscular response relating to safety education, the investigator found that "don't" instruction was slightly more effective than positive instruction in which the subjects were told what behavior was expected of them.[1] But it is not certain that this conclusion should be generalized to apply to typical school situations. This investigator also found that "verbal instructions unsupported by other forms of stimulation are relatively ineffective, especially with children."[2]

3. The Law of Readiness.—The Law of Effect merely specifies that the effect of the exercise of a modifiable connection between a situation and a response depends upon the concomitant satisfaction or dissatisfaction. There is need for another law that specifies the conditions that determine the nature of this affective phase of the total response. Thorndike[3] has proposed the Law of Readiness, which may be stated as follows:

*When a series of neurones and their synaptic connections*

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[1] VAUGHN, JAMES.—*Positive Versus Negative Instruction.* New York: National Bureau of Casualty and Surety Underwriters, 1928, p. 163.

[2] *Ibid.*, p. 164.

[3] THORNDIKE, E. L.—*Educational Psychology*, Vol. II. New York: Teachers College, Columbia University, 1913, pp. 1–2.

*are in a state of readiness, the passage of a nerve impulse along this series is satisfying; the absence of a stimulus that produces this neural activity is annoying. Annoyance also occurs when a conduction unit not in readiness is forced to function.*

Although we do not know the nature of the physiological condition in neurones and synaptic connections that constitutes a state of readiness or that constitutes a state of not being ready, this law appears to furnish an explanation in conformity with our observation of human behavior.[1] Hence we may accept the Law of Readiness as a working hypothesis and inquire concerning the source of states of readiness to respond to stimuli. The child is equipped by nature with certain satisfiers and annoyers.[2] This statement means that by nature he is so equipped that he is "ready" to make certain responses to certain situations and not "ready" to make other responses or to respond to other situations. By learning he acquires other satisfiers and annoyers.[3] In order to secure learning that is efficient from the point of view of the Law of Readiness, the teacher faces the task of creating a state of readiness, if it does not exist, before the learning exercise is presented. This principle of teaching is frequently expressed by saying that the teacher should arouse a state of interest, or create an appropriate mind-set. The Law of Readiness is applied by the public speaker when he endeavors to "put his audience in an appropriate frame of mind." Listening to what he has to say then becomes satisfying. A state of readiness is probably a preliminary response to a stimulus. For example, a readiness to eat

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[1] See the discussion of feeling as a response, on pages 96f.

[2] THORNDIKE, *op. cit.*, Vol. I, Chapter IX.

[3] See the discussion of reaction tendencies, pages 100f.

(commonly described as being hungry) is frequently a response to internal conditions, but it may be a response to the dinner bell, a clock showing the time for eating, or the words of a companion.

### Laws of Learning Relating to the Initial Formation of a Modifiable Connection between a Stimulus and a Response

The initiation of a connection between a stimulus and a motor response was explained under the head of conditioning reflexes, page 149. Experiments were described which showed that if a stimulus, which normally occasions a given reflex response, is presented simultaneously with a second stimulus that has no connection with this response, a connection will be initiated between this second stimulus and the reflex response. A reflex may also be conditioned by connecting a substitute response to a stimulus. The learning process appears to be similar when the response is predominantly mental.[1] For example, when an object such as an orange is first presented to a child so that it stimulates the visual receptors, the response includes certain sensations. The orange is a complex stimulus, and hence the child probably becomes aware of several of the object's characteristics, general contour, irregularities of surface, color, and the like. If the child is allowed to handle the orange, he makes certain other sensory responses. Observing his mother peeling the orange and eating it result in others. Since the various stimuli are operative simultaneously or are otherwise associated, the several responses tend to combine into a complex response. As a consequence the total response tends to be made when only one or a small group of the stimuli are operative. For example, the odor of the orange alone may stimulate a response that includes an image of the orange as a spherical object having a characteristic color. There may be also an image of eating it and of other sensory responses. In this way a complex response is built up and connected with certain stimuli.

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[1] See page 75.

**The Law of Association.**—The Law of Association, which has been proposed as an explanation of this initial phase of learning, may be stated formally as follows:

*Two or more stimuli, each capable of arousing a response, acting simultaneously or in contiguity, may arouse a joint response*[1] *which tends to become connected with one or more of the stimuli, with the result that it will be given when this stimulus or sub-group of stimuli is present.*[2]

The reader should note that this law states that the joint response *may* be formed. Laboratory experiments show that the responses to the separate stimuli do not always combine to form a joint response.[3] This probably can be explained by saying that the connections involved in the joint response were not sufficiently strengthened in accordance with the Law of Exercise and especially with the Law of Effect to function on a subsequent occasion. For example, when a stranger is introduced to a person, the latter makes a visual response to the stranger's presence, he hears the name, and perhaps pronounces it. The name-response *may* combine with the visual-response so that, if the stranger is met the next day, the name can be spoken. Frequently the connection is so weak that the name cannot be recalled.

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[1] This statement is subject to the qualification that the separate responses to the stimuli must not be mutually exclusive.

[2] This Law of Association is similar to the statements made on pages 85 and 164.

[3] Woodworth, R. S.—*Psychology.* New York: Henry Holt and Company, 1921, pp. 397f.

The Law of Association assumes that each of the stimuli is capable of arousing a response. Hence this law does not explain the initial formation of connections—only the formation of new connections out of old ones.[1] There is need for a law that will explain the initial formation of "new" stimulus-response connections. For this purpose Woodworth[2] proposes the supplementary Law of Combination. This law assumes the existence of "loose linkages," and states that two or more stimuli, each of which is so loosely connected with a response that it will not produce it, "may work together and arouse a single response." Woodworth believes the existence of these "loose linkages" is justified by the facts of "playful behavior and trial-and-error behavior." Their source is partially native but probably is largely the previous experience of the child. Connections that are not exercised tend to deteriorate, and it is easy to understand how there may be a vast number of "loose linkages" in childhood or later life.

Examination of the Law of Association and the supplementary Law of Combination leads to the conclusion that the essential feature of initiating new connections is exercise accompanied by a state of satisfaction. The physical mechanism provides the possibility of a vast number of stimulus-response connections.[3] When a nerve impulse originating in a receptor reaches the brush end of a neurone it is possible for it to arouse adjacent dendrites. Their form and arrangement make several different responses possible, and a particular connection is initiated by exercising it, that is, by the passage of the nerve impulse through a synapse. A "loose linkage" probably represents a synapse or series of synapses through which conduction is somewhat easy, and the exercise tends to change it so that conduction through it is facilitated on future occasions. The Law of Association and the supplementary Law of Combination may, therefore, be considered superfluous; still they may serve a useful purpose by calling attention to the operation of the Laws of Exercise, Effect, and Readiness in the initiation of modifiable connections.

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[1] This process is sometimes described in terms of substitute stimulus and substitute response.

[2] Woodworth, *op. cit.*, pp. 398f. For the application of this law, see pp. 401f.

[3] See page 29.

**Concluding statement.**—The learning process has been described in this chapter primarily, though by no means exclusively, from the point of view of the products, or effects, of the process. We have spoken of (1) the conditioning of reflexes, (2) the modification of instincts, (3) sensori-motor learning, (4) perceptual learning, (5) learning through contiguous responses, (6) the learning that occurs in problem solving, and (7) the acquisition of general patterns of conduct.[1] These seven types of learning are the result of an analysis of the changes produced by learning rather than of the activities in which the learner engages, though they can hardly be said to have been derived exclusively from either source.

It appears desirable to present a second analysis of learning—this time from the point of view of the learner's activities. Such an analysis should add much to the reader's understanding of the teacher's task of stimulating and directing learning activities in the school.

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[1] These seven types of learning are not to be conceived as seven unrelated, mutually exclusive types. On the contrary, a given case of learning may exhibit features that would justify its inclusion in two or more of the types. It appears, however, that all seven types are necessary in order to account for all the changes produced in a human being by responding to stimuli.

## LEARNING EXERCISES FOR THE READER

1. Describe two cases of problem solving from your own experience and show that learning occurred in each case.
2. Describe three cases of trial-and-error learning from your own experience.
3. Pick out five statements in the chapter that are clearly in agreement with the principle that learning is an active process.
4. Contrast the three types of sensori-motor learning described on pages 152f.
5. What is a learning curve? What did the learning curves presented in this chapter contribute to your understanding of the learning process? Be specific in your answer.
6. Select three general patterns of conduct that you think you have acquired, and describe in so far as you can the process by which you learned each of them.
7. What is the meaning of the verb "condition" as used in this chapter?
8. Distinguish between "learning to perceive" and "learning through perception."
9. Give from your own experience five illustrations of "learning by contiguity of response."
10. Give three illustrations of learning that involves substituting one stimulus for another; also three illustrations of substituting one response for another.
11. What important difference is there between learning in the case of acquiring motor skill and learning in forming fixed associations?
12. What mnemonic devices have you found helpful?
13. Suppose that on fifteen trials of five minutes each on a substitution test your scores, taken in order from the first test to the last, are: 22, 29, 36, 42, 45, 51, 49, 56, 60, 61, 67, 65, 70, 69, 74. Construct your learning curve, leaving the scores in terms of work done in five minutes of time.

14. Assuming the same scores as in the preceding exercise, construct your learning curve when progress is measured by the decrease in time required to make one hundred substitutions, assuming that the rate of work each day would have been maintained until one hundred substitutions were made.

15. This chapter sets forth a considerable number of laws and principles relating to the learning process. Prepare a summary list of them, stating each clearly and concisely.

16. Is it fortunate or otherwise that repetition does not always strengthen tendencies toward responses? Explain.

17. Are all general patterns of conduct commendable? Does the bootlegger possess general patterns of conduct that function in his activity?

Intelligence + past exp. (acquired traits) = learning activity
+
Stimuli {Learning Exercises + others

# CHAPTER VI

## LEARNING IN SCHOOL ACTIVITIES

**Relation of this chapter to the preceding.**—Obviously the discussion in this chapter will include a repetition of some things that have been said in the preceding one, but the reader should welcome this supplementary treatment. Exercise of modifiable connections is necessary if these connections are to become strong enough to be effective controls of conduct, and are to possess the quality of permanency. Hence, the study of the learning process in the preceding chapter, even when supplemented by doing the learning exercises at the end of the chapter and by participating in the classroom discussions, probably will not result in an adequate understanding of this important topic of educational psychology. In addition to providing a basis for learning activity that should produce some important supplementary ideas, the present chapter affords the reader an opportunity to exercise what he has learned from his study of the preceding one. The primary purpose of the chapter, however, is to describe the learning process from the viewpoint of the learner's activities, rather than from the viewpoint of the changes made in the learner. Hence the first problem is to identify the activities of the school in which learning occurs.

**The learning activities of the school.**—If one observes pupils in the classroom, study hall, laboratory, and other places where they engage in learning activities, he will find them drawing, playing the piano, playing basket ball, studying maps, manipulating laboratory apparatus, reading, writing themes, listening to explanations by the teacher, observing demonstrations, answering questions, planning an assembly program, solving arithmetical problems, and engaging in still other activities. Obviously it is not feasible to list in detail all the various activities in which pupils participate, for the list would be a very lengthy one. Furthermore, some of the activities are complex. For example, reading is an activity that varies in its essential characteristics and may be analyzed into several types.[1] Consequently in attempting to describe the learning activities of the school, it is necessary to employ a classification.

**A classification of the learning activities of the school.**—The following classification is offered as a basis for describing the major learning activities in which pupils engage. The present writers are aware that other classifications might be defended, but this one has seemed most helpful for our purpose.

1. Making overt muscular responses
2. Perceptual experiencing
3. Vicarious experiencing[2] (occurs in observing, reading, and listening)
4. Generalizing experience, both perceptual and vicarious (one type of thinking)
5. Comprehending the products of generalization by another person[3] (occurs in reading and listening)

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[1] For one analysis see MONROE, W. S.—*Directing Learning in the High School.* Garden City, New York: Doubleday, Doran and Company, Inc., 1927, pp. 193f.

[2] This activity consists primarily in acts of imagination.

[3] This is mainly "association" but thought processes are involved.

6. Manufacturing responses to new situations (problem solving)
7. Tracing the thinking of another person (occurs in reading and listening)
8. Expressing one's ideas[1]
9. "Prolonging, repeating, and intensifying one's experiences"
10. Affective experiencing

In presenting this classification the present writers do not intend to imply that the activities of pupils may not consist of a combination of two or more of these types. In fact, this is frequently the case. Furthermore, during brief periods of study a pupil may shift from one type of activity to another.

**1. Making overt muscular responses.**—Making overt or observable muscular responses to stimuli represents a type of learning activity, but not all overt muscular activity should be classed as educative. For example, the walking of the adult is a case of overt muscular activity, but it does not normally result in learning to walk faster or more gracefully. The explanation probably is that the adult has reached a plateau[2] in learning to walk. Possibly he may have reached his limit of improvement. Hence, "making overt muscular responses" should be understood to refer to activity that has not become mechanized.

In the school, this type of learning activity is prominent in handwriting, typewriting, athletics, shop work, piano playing, and the like. Muscular activity that is indirectly observable occurs in oral reading and in speaking a foreign language. Outside of school, the child also engages in educative muscular activity.

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[1] Involves thought processes.

[2] See page 174.

The educative effect of overt muscular activity is governed by the conditions implied in the laws of learning. The connection between a stimulus and a response is strengthened in accordance with the Law of Exercise and the Law of Effect. When the response is exercised, it is strengthened, provided "a satisfying state of affairs" prevails; but in order to have efficient learning, the subordinate Law of Intensity must be satisfied. Hence the repetition of an act does not necessarily result in learning. In order to be efficient as a learning activity, practice in handwriting, typewriting, piano playing, and the like must be "intense" or attentive, and it must be satisfying.

In the early stages of learning to make a muscular response to a stimulus, especially a response that consists of a series of movements, the correct movements are selected by the "trial-and-error" process. The selection of the correct movements, however, is dependent upon satisfaction resulting from making them, and annoyance resulting from making incorrect movements. This is illustrated in handwriting. If the child's purpose is merely to write the copy ten times, or to produce a required theme, he is not likely to be annoyed by imperfections in his handwriting. The teacher cannot always depend upon the operation of the "trial-and-error" processes; it operates only under the conditions implied by the Law of Effect.

As suggested on page 156, the period of learning can be greatly reduced by appropriate demonstrations and directions, but the pupil must perform the act, and the effect of his activity is governed by the laws of learning. There can be too much demonstrating and giving of directions.

In addition to being a means of learning to perform an act, making overt muscular responses is a source of a type of perceptual experiencing. This point need not be elaborated here since it more properly belongs under the next head.

2. **Perceptual experiencing.**—The child has engaged in a large amount of perceptual experiencing before he enters school, and he continues the activity outside of the school; but schools make provision for certain types of perceptual experiences. This learning activity occurs in laboratory work, field trips, listening to music, observing demonstrations, and looking at pictures, charts, maps, and diagrams. A very significant type occurs in associating with other pupils and with the teacher, especially in extracurricular activities. The making of overt muscular responses provides a unique type of perceptual experiencing through the kinæsthetic sensations. Much of the discussion of perceptual learning in the preceding chapter is applicable here. There are, however, certain points that deserve emphasis. The effectiveness of perceptual experiencing as a learning activity depends upon the nature of the learner's activity. In order that the activity of perceiving may be highly educative, the pupil must have learned how to perceive. Furthermore, he must do more than merely observe. The Law of Intensity is especially significant in this connection. A pupil may observe a laboratory demonstration or take a field trip and learn very little. Another pupil may learn much. The difference in their achievements is due to differences in their activities. Although they may have appeared to do the same things, their activities have differed in significant respects.

If a field trip is to be highly educative, the pupil must know what to look for. He must have a purpose to direct his perceptual experiencing. For example, a child may "observe" many different kinds of trees, but if he has no purpose he is not likely to learn to recognize the maple, hickory, elm, oak, cottonwood, etc. Later this child may go on a field trip with the purpose of learning to recognize the different kinds of trees and achieve this purpose during a single trip. Many persons "observe" birds, but relatively few learn to identify very many of them. The explanation is that very few persons are interested in birds. A visitor to a museum "sees" the exhibits, but if he has no definite purpose, he learns very little. Gates[1] tells of an investigation in which a large number of students were asked whether the four on their watches was IV or IIII. "Of 200 students whose watches carried a IIII, 179 declared it was IV." Although these students had looked at their watch faces many times, they had not learned the form in which the four appeared.[2]

Effective perceptual experiencing requires discrimination. To the untrained observer two oak trees may appear to be essentially alike, but the trained observer may see many significant differences. A foreign language that we do not understand seems to be a meaningless jumble of sounds but it is not any more so than our own language. The characters of the Chinese language seem to be very much alike but a person who has learned to read this language experiences no difficulty in noting significant differences. The expert botanist learns more from a field trip than the untrained observer because he "sees" many things that are not apparent to the other.

3. **Vicarious experiencing.**—Vicarious or secondhand experiencing may be contrasted with perceptual or direct experiencing. In the latter, there is always functioning

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[1] Gates, A. I.—*Psychology for Students of Education.* New York: The Macmillan Company, 1923, p. 267.

[2] See Learning Exercise 18, page 224.

of one or more sense organs, which supply the sensations that form the basis of the perceptual activity. In vicarious experiencing there is no such functioning of sense organs. Instead the child builds up images in his mind in response to descriptions or illustrations of perceptual experiences. For example, a reader of a well-written description of a football game may build up images of the field, the stadium, the crowd, the marching and playing of the band, the cheering, and the plays of the game. The material for these images is drawn from the reader's previous perceptual experiences, modified perhaps by subsequent vicarious experiences; consequently two persons reading the same description may build up images that differ in many respects.

Vicarious experiencing may be combined with perceptual experiencing. The observer of a football game experiences the playing of the game vicariously, but in contrast with the person who merely reads an account of the game, he has a perceptual experience as an observer of the spectacle. Similarly, a student observing a laboratory demonstration has a type of perceptual experience, but he experiences only vicariously the manipulation of the apparatus.

Learning to experience vicariously is not a simple matter. In vicarious experiencing the things perceived are verbal symbols or other means of description. The perception of these things represents a more mature process than the perception of a familiar object. The ability to perceive an orange, a chair, a pet, a toy, or a playmate, is acquired early in life. Ability to perceive a written description of a toy, an animal, a game, a chair requires that the child be able to read. In the first place there must be adequate prerequisite perceptual experiences.

Without them a person would be unable to build up the mental picture. However, the amount of perceptual experiencing required is not necessarily large. Persons handicapped by the loss of sight or other senses frequently are able to engage in vicarious experiencing for which they have had relatively little direct preparation. In the second place, the pupil must become able to associate appropriate meanings with the words used in the description.

Vicarious experiencing is not a passive process. The reader or listener must be active—that is, he must build up a clear and sometimes a detailed mental picture of the scene, event, person, or thing described.[1] The pupil must engage in constructive imagination.[2] Sometimes he may draw a diagram to represent the scene, event, or thing described. Frequently he may need to reread the description.

Vicarious experiencing is an important learning activity in school. The student can experience vicariously historical events, current events, scenes in distant places, machines in commercial plants, and the like, which it would be impossible for him to experience directly. Some instructors in science classes substitute demonstration lectures for individual laboratory work, and investigations have indicated that superior results can be secured by doing so.[3]

4. **Generalizing experiences.**—This learning activity involves thought processes[4] in which concepts, rules, and

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[1] This statement represents an application of the Law of Intensity.

[2] See page 88.

[3] Downing, E. R.—"A Comparison of the Lecture-Demonstration and the Laboratory Methods of Instruction in Science," *School Review*, 33:688–97, November, 1925.

[4] See pages 90f.

principles are developed from experiences both perceptual and vicarious. These thought processes are frequently called inductive development, which is described in terms of analysis, abstraction, comparison, classification, and organization. Inductive development has been emphasized as a learning activity by a number of writers who are usually referred to as Herbartians.[1] They described the inductive development lesson in terms of five steps—(1) preparation; (2) presentation; (3) association, comparison, and abstraction; (4) generalization; (5) application. Although the fourth step is named "generalization" it is obvious that the process is begun in the third.

Inductive development as conceived by Herbartian writers does not appear to be a satisfactory description of the learning activity of generalizing experiences. The thought processes are not as systematic as the statements in the preceding paragraph imply. A hypothesis (tentative generalization) may be made after a very few experiences, sometimes after a single experience. This hypothesis is then verified by comparison with other experiences and with knowledge previously acquired. In case the comparison reveals inconsistencies, another hypothesis is made and the process of verification repeated.

In order to secure strong S→R bonds it is necessary to exercise them. Recalling perceptual and vicarious experiences, comparing them, and formulating generalizations represents an important type of exercise. The pupil who is asked to compare several plants that he has observed and to point out their similarities and their differences strengthens the products of his observation in addition to adding the generalizations formulated. A motorist experiences the roads he passes over. The rough places, steep grades, sharp turns, detours—all produce vivid experiences; but after the lapse of a few days during which there has been no recall of these experiences, the resulting S→R bonds lose much of their initial strength. If a friend asks concerning the condition of the roads encountered on the trip, the motorist will probably be surprised to find that he has forgotten many of the details of his experiences. Furthermore, if he has not thought about the question of the general conditions of the roads, either at the time of his trip or since, the motorist will have to think (generalize) before he can answer his friend's question. If he now does so, and is able to recall his experiences, he will find that a number of S→R bonds have been strengthened. Furthermore, he has added to his knowledge of road conditions by generalizing.

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[1] Herbart (1776–1841) through his *Outline of Educational Doctrines* (originally published in 1835; translation, The Macmillan Company, 1901) influenced the educational theory of a group of educators in the United States who at one time were known as Herbartians. The steps of a development lesson given here were formulated by followers of Herbart in the United States, among whom Charles DeGarmo, Charles McMurry, and Frank McMurry were perhaps the most prominent. See McMurry, C. A., and McMurry, F. M.—*The Method of the Recitation*. New York: The Macmillan Company, 1903, pp. 74–235. Bagley, W. C.—*The Educative Process*. New York: The Macmillan Company, 1905, pp. 285–304. Colvin, S. S.—*An Introduction to High School Teaching*. New York: The Macmillan Company, 1917, pp. 295–309.

This illustration suggests why pupils frequently learn little from perceptual and vicarious experiencing. Dewey points out that the introduction of provisions for perceptual experiencing represents "a distinct advance over the prior method of linguistic symbols," but this advance is only a "halfway step."[1] Both perceptual experiencing and vicarious experiencing lose much of their value if they are not supplemented by the process of generalizing. In other words, the student should think over his experiences. He is not very likely to do this, however, unless learning exercises are assigned which will provide the necessary stimuli. Generalizing, as well as the other types of thought processes, is a response to a stimulus. It does not occur spontaneously. The stimulus is commonly described as a difficulty, a perplexing situation, or a problem.

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[1] DEWEY, JOHN.—*How We Think.* Boston: D. C. Heath and Company, 1910, p. 140.

**5. Comprehending the products of generalizing by another person.**—A person can learn generalizations by comprehending the conclusions reached by another person. This affords a "short cut" in acquiring knowledge. Comprehending the products of generalization makes possible an enormous economy of time for the learner. If it were not possible for one generation to appropriate the generalizations made by the preceding, there could be relatively little progress from generation to generation.

Comprehending the products of generalization is not a passive process. It involves thinking. In some respects it is the reverse of generalizing experience. In comprehending a generalization, the learner begins with the product of another person's thinking expressed in terms of symbols. For example, in reading this page the student comprehends certain products of the writer's thinking. He associates meaning with the printed words and phrases and then combines these knowledge elements into the meaning of sentences and paragraphs. If "new" words and phrases are encountered, he must formulate meanings for them. The formulation of a meaning, either of a word or of a sentence, is at first a hypothesis which must be verified.[1]

Comprehending the products of generalization requires an adequate vocabulary and this in turn requires a foundation of experiences, perceptual and vicarious, supplemented by generalizing. The truth of this statement is apparent when a person attempts to comprehend a technical discussion in a field with which he is relatively unacquainted. He is handicapped by not knowing the meaning of the technical terms used; but the difficulty is likely to be more fundamental. A dictionary or other sources may be consulted for the meaning of words, but the comprehension of the definitions given is dependent upon a foundation of prerequisite meanings, some of which are derived from experiences.

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[1] The process of reading is described more fully on pages 452f.

Comprehending the products of generalizing that are recorded in textbooks is emphasized as a learning activity in our schools. This is appropriate, but the complaint is frequently made that pupils learn the words in which the generalizations are expressed rather than their meaning. The explanation of this condition is that the pupils engage in memorizing statements rather than in comprehending them. In other words, the pupils fail to make the response that is expected of them. One reason why they do not engage in comprehending is that they have not acquired adequate ability to do so. Training is necessary in order that a pupil be an effective perceiver. Comprehending generalizations is a more difficult process, and training is required in order to become efficient in it. Investigation[1] has revealed that many students in the high school and even in college are not good readers.

Obviously a teacher is not justified in assuming that a request to read certain pages will result in comprehension of the generalizations. The request cannot serve as an adequate stimulus, unless the pupils have learned how to engage in this type of reading. Furthermore, the activity, to be effective, must result in satisfaction. The conditions governing satisfaction and annoyance in this case are subtle, and hence difficult to describe, but they are determined in part by the teacher's attitude and the tests he employs in measuring the learner's achievement. If the questions asked call for verbatim statements from the text, the pupil will derive satisfaction from memorizing, and hence will not feel any need for comprehending.[1]

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[1] See pages 419f.

**6. Using knowledge in manufacturing responses to new situations.**—This learning activity is essentially the same as problem solving, which was described in Chapter V.[2] A longer name is used here to emphasize the idea that the activity involves using one's knowledge and making a response to a *new* situation. As used here the term "new situation" means one that perplexes or presents a difficulty. If there is no problem, there can be no reflective thinking.

The process of reflective thinking was described in Chapter III, pages 92–96, and the nature of the outcomes was noted in Chapter IV. Consequently it is unnecessary to consider either the process or the outcomes here. There are, however, certain points that deserve attention. Reflective thinking is commonly thought of as being limited largely to mathematics and those other subjects which involve problems requiring mathematical calculations. This is not true. In attempting to solve mathematical problems, which is generally interpreted to mean obtaining the correct answer, many pupils do not use their knowledge in manufacturing a response to the problem. Instead, they attempt to recall the method used in solving a similar problem, or proceed to manipulate the numbers given in the hope that a satisfactory answer may be obtained. Even in the case of pupils who are willing to think, problems that may be solved by applying a well-established procedure do not afford much occasion for reflective thinking. On the other hand, there are many thought questions in history, geography, English literature, and other school subjects; and, in general, these are far more numerous than the occasions for reflective thinking in mathematics, provided, of course, the teacher asks thought questions and allows time for reflection before an answer is required. Occasions for using knowledge in manufacturing a response to a new situation also occur in the shop and laboratory and in extra-curricular activities.

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[1] This point is elaborated on pages 544f.

[2] See page 183.

Using knowledge in manufacturing responses to new situations is an important learning activity. As pointed out on page 183, a person's knowledge grows as he uses it. If he does not use it, it atrophies. Modifiable connections must be exercised if they are to retain their strength. It is especially important that knowledge acquired through reading or listening be exercised by using it.

7. **Tracing the thinking of another person.**—This type of learning activity occurs when one listens to or reads a description of the thinking of another person. It differs from "using knowledge in manufacturing a response to a new situation" in that when the pupil "traces the thinking of another person" he is a follower, whereas in solving a problem he is relying upon his own initiative and resourcefulness. "Tracing the thinking of another person" occurs in the study of geometry when the pupil reads the demonstration of a theorem. Any one who has studied geometry is aware of the difference between studying a demonstration given in the text and doing an original exercise. The

latter is a case of "using knowledge in manufacturing a response to a new situation."

"Tracing the thinking of another person" suggests a relatively passive process. It, however, cannot be passive if it is to function as a learning activity. A reader or listener, in order to learn, must be active mentally. Any tendency toward inactivity means a decrease in the effectiveness of the reading or listening as a learning activity. Since a writer presents the ideas and lays out the "paths of thinking," it is very easy for the reader to become passive. The situation is similar to the visit of a tourist in a strange city under the direction of a competent guide. If he merely follows his guide, he will learn very little about the geography of the city, and later, if unaided, he will probably be unable to find his way about. On the other hand, if this tourist studies a map of the city, notices landmarks and pays attention to the route over which he is guided, he probably will be able to retrace the route without a guide, or to serve as a guide for another tourist. In reading a record of thinking, the student is the tourist and the author an expert guide. If the student is merely a follower, he will learn little from the reading of the textbook. He will not be able to reproduce the thinking about the topic.

"Tracing the thinking of another person" should be distinguished from mere memorization of knowledge symbols. Thought processes are involved in comprehending the description given by the other person. If his argument is not described clearly, the reader or listener may find the tracing difficult. Occasionally he may need to fill in gaps.

**8. Expressing ideas.**—Expressing ideas includes more than merely speaking or writing certain words. There must also be some formulation, evaluation, and organization of the ideas.[1] A writer may be familiar with a topic, but his ideas may lack definiteness and organization. In other words, his ideas may not be clearly and completely formed, and he may not have arranged them in a satisfactory order. Furthermore, the first selection and organization of words may not accurately express the ideas. A writer or speaker who is critical of his own expression frequently rejects words and phrases that occur to him because, when examined critically, they do not appear to express accurately and precisely the ideas intended.

On page 208 attention was called to the fact that experiencing, both perceptual and vicarious, was necessary but not sufficient. The requirement of a report of a field trip affords opportunity for a learning activity that supplements in a valuable way the perceptual experiencing of the trip. If the assignment requires comparison with other experiences or the application of facts and principles learned in class, the student's expression will involve generalization and other types of thought processes.

**9. "Prolonging, repeating, and intensifying one's experiences."**[2]—The term "experience" in this phrase has a somewhat broader meaning than it has in "perceptual experience" or "vicarious experience." As used here it is essentially synonymous with "learning activity." One learns by prolonging and repeating any of the types of activities described in the preceding pages.[1] In fact, some repetition is required to secure the quality of permanency in the outcomes. An S→R connection that is not exercised grows weaker.[2]

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[1] The reader should bear in mind that this type of learning activity is not intended to include repeating of memorized statements. As used here, "expressing ideas" implies that the ideas have not been completely formulated in terms of symbols in the mind of the learner. Furthermore, it is assumed that the one "expressing his ideas" is giving some attention to what he is saying or writing and to the effectiveness of his expression.

[2] This phrase is suggested by Bobbitt, Franklin.—*How to Make a Curriculum.* Boston: Houghton Mifflin Company, 1924, p. 57.

"Practice" and "drill" are commonly used as names for learning activity involving repetition, but the meaning associated with these terms represents a somewhat more limited concept than is intended here. Students "live over" perceptual experiences; they recall what they have read or heard: they rethink through the solution of a problem; they retrace the thinking of another; they reassociate a meaning with an abstract or general term. Such activities contribute to the learning resulting from the original experience, and their contributions are important. The Law of Exercise makes it clear that strong controls of conduct do not result from a small amount of exercise. Usually it is necessary to supplement the learning that occurs in observing, reading, and listening. The ideas, meanings, and concepts which result from these activities need to be strengthened, evaluated, and organized. Summarizing and outlining are two types of activities that come under this head. Taking notes on a reading assignment or a lecture is another. A pupil, however, may supplement his observing, reading, and listening by thinking over his experience.

Although it is frequently necessary to make formal provisions for the exercise of S→R connections, some repetition of connections initiated is secured through learning activities that are commonly described as "new." For example, in manufacturing a response to a "new" situation a person exercises a portion of his knowledge. The fundamental arithmetical combinations are exercised in calculating the answer to a problem. There is practice in handwriting and spelling in writing a theme.

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[1] See in this connection the Law of Exercise, page 188.

[2] See the topic of "forgetting," pages 179f.

In order that "prolonging, repeating, and intensifying one's experiences" may be efficient as a learning activity, the pupil must focus his attention upon what he is doing. The Law of Intensity is applicable here as well as in connection with the other learning activities. Reviewing is often ineffective because it is superficial. It is important to bear in mind that repetition does not insure learning.[1]

The term "cramming" has been used to designate a type of reviewing in which students sometimes engage just prior to a final examination. Usually the term is intended to imply that the learning activity is confined largely to memorizing knowledge symbols, and that the student has neglected the assignments throughout the term. Neither of these practices can be defended, but intensive reviewing just prior to an examination or at any other time may be a valuable learning activity. Other things being equal, the more intense a learning activity is, the more beneficial it is. Furthermore, the Law of Exercise makes it clear that there must be repetition if strong S→R connections are to be secured. There is probably too little of intense reviewing. Cramming, therefore, if it is of the right sort, is a desirable learning activity.

In the statement of the Law of Exercise[2] it was pointed out that practice is more efficient when it is distributed. This means that if there are to be one hundred repetitions of a given S→R connection, other things being equal, the strengthening effect will be greater when the repetitions are distributed over several weeks or months than when confined to a single period of practice. Thorndike has recommended the following distribution for learning an easy multiplication combination: "twelve practices in the first week of learning, supported by twenty-five practices during the two months following, and maintained by thirty practices well spread over the later periods."[1] Less systematic repetitions, which have been described here as "prolonging, repeating, and intensifying one's experiences," should also be distributed in order to be most effective.

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[1] See pages 189f.

[2] See pages 188–89.

**10. Affective experiencing.**[2]—As the term implies, the response in this activity is affective rather than cognitive or ideational. It is commonly described in terms of emotion and feeling. It involves responses of the type designated as reaction tendencies.[3] Affective experience does not occur independently, but rather as a concomitant of the learning activities described in the preceding pages. The affective response is a phase of the total response.[4] At times it may dominate the conscious state, as in listening to music or an inspirational address, viewing a landscape, participating in group singing or a pep meeting, and the like. At other times it is subordinated to the physical and intellectual phases of the activity—as in solving an original exercise in geometry, reading an exposition of a principle in physics, writing a theme for the English class, practicing on a typewriter, or listening to an explanation of the solution of a problem in algebra.

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[1] THORNDIKE, E. L.—*The Psychology of Arithmetic*. New York: The Macmillan Company, 1922, p. 133.

[2] For a psychological exposition of the affective elements of consciousness see ANGELL, J. R.—*Psychology*. New York: Henry Holt and Company, 1908, Chapter XIII.

[3] See page 100.

[4] See page 96.

It is relatively easy to stimulate a desired muscular response. It is not very difficult to stimulate perceptual experiencing and the other cognitive learning activities. It is more difficult to stimulate affective experiencing. In general a given affective response cannot be secured by making a direct request for it. For example, pupils are not likely to enjoy reading an assignment because the teacher asks them to enjoy it. Pupils are requested to practice typewriting for a certain period each day, but it would be absurd to request pupils to appreciate a picture for twenty minutes. Instead, the teacher talks about the picture, giving evidence of his appreciation and hopes that the pupils will make the desired affective response. Usually a desired affective response must be secured by some such indirect stimulation.

An affective response may become connected with a class of situations rather than with a particular stimulus. For example, the affective response commonly called appreciation may be connected with music of the type called classical, and as a result this appreciation response will be made to a new musical selection the first time it is heard. Detailed analysis probably would show that the new musical selection included a number of old stimuli; but, for practical purposes, we may say that the appreciation response was made to a new situation the first time it was encountered. The initiation of a connection between a class of situations and an affective response is a type of learning.

Affective experiencing is implied in the Law of Effect. Hence the nature of the affective response accompanying a learning activity determines to a large extent the outcome of that activity. Affective experiencing is especially important in acquiring the controls of conduct called general patterns of conduct. A child cannot acquire an ideal or an interest without engaging in some affective experiencing.

**Need for a "balanced ration" of learning activities.**—The need for supplementing certain learning activities by others has been referred to in the preceding discussion. This need is more general than has been indicated. In order that a child's efforts be most effective, the learning activities in which he engages should constitute a "balanced ration." Perceptual experiencing is essential, but too much of it results in inefficiency in learning. Vicarious experiencing is more economical under certain conditions. The pupil should generalize his experiences, but he should also take advantage of the "short cuts" afforded by comprehending the generalizations made by other persons. At times he should use his knowledge in manufacturing responses to new situations. Likewise he needs to engage in each of the other learning activities.

The exact proportion of the several learning activities that are required for a "balanced ration" cannot be specified, but it appears likely that under present conditions comprehending generalizations and tracing the thinking of other persons[1] occupy too much of the pupil's time. It is relatively easy for the teacher to assign references to be read or to request the pupil to listen to explanations, and consequently many pupils spend a large proportion of the time devoted to school work in reading and listening. A "balanced ration" of learning activities would probably include less of reading and listening, and more of using knowledge and expressing ideas. It is also probable that more time should be given to "prolonging, repeating, and intensifying experiences."

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[1] Both of these activities occur in reading and in listening.

**Factors affecting learning activities.**—The responses of a pupil to learning exercises[1] are affected by a number of factors. For example, if a thought question is proposed to a class, there may be as many different responses as there are pupils in the class. For one pupil the question may stimulate the recall of a statement he has read; another may proceed to think out an answer reflectively; a third may offer the first plausible answer that comes into his mind; a fourth may think about the question casually, not attempting to formulate an answer; a fifth may classify the question as difficult and give up; a sixth may interpret the question erroneously. Some of the factors that influence the pupil's responses are inherent in him or subjective; others are external, being supplied by his environment, which includes teacher, school, community, and home.

Learning exercises are complex in the sense that an exercise may include a number of stimuli. For example, in an assignment to read certain references, each sentence, and even each word and phrase which it contains, is a stimulus. In addition, the pupil is subjected to stimuli contributed by the teacher's personal appearance, voice, and personality, the pupil's classmates, size of class, the temperature of the room, the equipment, noises outside of the classroom, and several other factors that probably are of minor importance. If the reading is to be done at home, another group of stimuli is introduced. For example, the teacher of an eighth-grade class asks her pupils to "compare George Washington and Abraham Lincoln."

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[1] The name "learning exercise" is applied to the requests of the teacher, both explicit and implicit, made for the purpose of providing a basis for learning activity. The explicit requests include assignments of various types and the questions asked during the class period. The request to listen is implied when the teacher or a member of the class explains a problem.

Each of these names functions as a stimulus to which ideational responses are made. The pupil probably responds also to the word "compare." In addition he is likely to respond to the tone of voice in which the teacher assigned the task, his bodily posture, his personal appearance, and the like. Any peculiar mannerisms are likely to be especially noticed. The classmate who is a competitor for scholastic honors provides a stimulus to which the pupil responds with an attitude of attention. A small class is likely to make the pupil more alert than a large one. If the class includes several members who are brighter than the pupil called upon, he is likely to respond differently than if he were in a homogeneous group. The pupil's response is also affected by the manner of asking the question. If he is called on before the question is asked, his response will usually be different from the one he makes when the question is asked first.

The total response the pupil makes in a given case is determined by his native equipment together with the controls of conduct he has acquired. The latter include relatively fixed associations or specific habits, knowledge, and general patterns of conduct (interests, prejudices, attitudes, study habits, etc.). For example, in the case of the above question the pupil's response depends upon what he knows about Washington and Lincoln and upon the meaning he associates with the word "compare." It also depends upon his accustomed mode of responding to a question, his reactions to the teacher's voice, and the other stimuli to which he is sensitive. If it is "fashionable" to "act smart," his response will be influenced by this "mode of response." Some of the responses to the concomitant stimuli facilitate the desired learning activity; others are a handicap.

The function of a pupil's general patterns of conduct in determining his responses to stimuli is especially important. As pointed out in Chapter III, a state of attention is a response, and if the pupil has formed certain "habits of attention," he tends to make an attention response to certain stimuli. Since attention is "an attitude of readiness for what is coming next," a state of attention obviously contributes to the pupil's learning activity, and the absence of a state of attention detracts from it. In a similar way the responses classified under "feeling," "motives, impulses, and mental sets," and "emotion" affect a pupil's learning activity. In this connection it should be noted that these conscious states, especially those classified as "motives, impulses, and mental sets" tend to persist for some time, and hence a stimulus that operated at the beginning of the class period, or during the preceding hour, or even at some other previous time may contribute to the pupil's learning activity. For example, such events as a "pep meeting," an exciting party, a circus, or a serious accident are almost certain to influence the learning activities of pupils for several hours because they arouse responses of the type we are considering here. In a similar way the home and the general spirit of the school exert a potent influence.

In mathematical terminology the total response which we call the learning activity is a function of the pupil's intelligence, a number of acquired traits, and a group of stimuli. This statement may be expressed in terms of the equation:

$$\text{L. A.} = f(\text{l. e.}, I, t_1, t_2, t_3 \ . \ . \ . \ t_n, S_1, S_2, S_3 \ . \ . \ . \ S_n)$$

In this equation L. A. represents learning activity; l. e., the learning exercise; I, intelligence;[1] $t_1, t_2, t_3, \ldots t_n$ the various acquired traits and controls of conduct; and $S_1$, $S_2$, $S_3$ . . . $S_n$ the various stimuli other than the learning exercise to which the pupil is sensitive. If we knew the value of the various independent variables, and if we knew the form of the equation, we could calculate the learning activity. The situation, however, is obviously very complex and our knowledge of the laws governing responses is very limited. Furthermore, the teacher seldom knows a pupil sufficiently intimately to assign even approximate values to the various traits. Consequently accurate prediction is impossible, but this description should convince the reader that the actual learning activity of a pupil is the resultant of a number of factors of which the learning exercise is only one.

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[1] This term is defined in Chapter VIII, page 253.

Harold Stratton Garceau Σ.N.

**Concluding statement.**—This concludes the formal consideration of the learning process. It will, however, be referred to in several connections, especially in Chapters XII and XIII which are devoted to the psychology of school subjects.

## LEARNING EXERCISES FOR THE READER

1. Each of the chapters of this text includes a list of learning exercises for the reader. Can you justify these lists? Have you "learned" as the result of doing the exercises included in the preceding chapters? organize & generalize - use knowledge meet new pro

2. Distinguish between perceptual experiencing and vicarious experiencing.

3. Do you believe that college students have a balanced ration of learning activities? If not, how could a balanced ration be secured?

4. What bearing does the principle of distribution of practice have on the effectiveness of cramming? Is the ability to cram effectively of any value in life?

5. Read Dewey's *How We Think*, Chapter XV. Then criti-

6.

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cize the "Five Formal Steps" as a teaching procedure in developing generalizations.

6.✓ Select some school subject—say, geography, geometry, or physics—and show that all ten types of learning activity may be represented in studying that subject.

7. Can you think of any learning activity that cannot be placed under any of the ten types described in this chapter?

8. Which, if any, of the ten types of learning activity do you think occupy too large a place in ordinary schoolroom practice? Which, if any, do not receive sufficient emphasis?

✓ 9. Why is lecturing generally considered a poor method of teaching? What may an instructor do to increase the effectiveness of this method? Justify each technique you propose.

10. What types of learning activity are prominent in the study of the following subjects as they are commonly taught: arithmetic in the intermediate grades, geography, geometry, spelling, history, English literature, physics.

11. What is the meaning of the phrase, "well-balanced ration of learning activities"? Do the learning activities that you listed for the subjects in the preceding exercise form a "well-balanced ration"? If not, what changes would you suggest?

12. In what types of learning activity do you engage as you study this text? What types do you engage in during the recitation period? Do these types form a well-balanced ration?

13. When is vicarious experiencing to be preferred to perceptual experiencing?

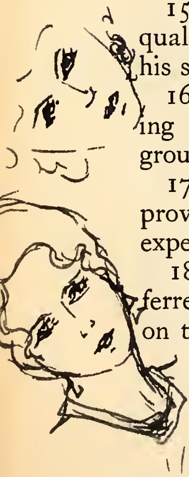
14. Explain how a student's knowledge grows as he uses it.

15. A teacher's personality is considered an important qualification. How does it affect the learning activities of his students?

16. Under what conditions may students profit from studying together? Would you advise students to study in small groups when it is feasible to do so? Give your reasons.

17. Do you think teachers in high school and college usually provide for enough "prolonging, repeating, and intensifying of experiences"? Give your reasons.

18. Explain why over three-fourths of the students referred to on page 204 had failed to learn the form of the four on the dial of their watches.



*Four things necessary for personality of a teacher:—

1.
2.
3.
4.

*By Palmer-

Laws of Learning
Exercise
Effect
Readiness

## CHAPTER VII

CHAPTER VII

## TRANSFER OF TRAINING

TRANSFER OF TRAINING

**The basic problem.**—The basic problem under the head of transfer of training is usually expressed in the form of a question, such as: "Do the outcomes resulting from the study of geometry include some that will increase[1] a student's ability to answer thought questions in history?" Or to state it more briefly but less precisely: "Does training in one field transfer to another?"

The use of the phrase, "transfer of training," dates back to the time when faculty psychology was generally accepted, and for this reason it now probably suggests some unfortunate implications to many persons. "Training" suggests "mental faculties" or traits possessing similar characteristics. "Transfer" suggests actual movement or change of location. As used in the phrase "transfer of training," it does not necessarily have this meaning. The phrase should be thought of as a name for a mental phenomenon in which there is an effect similar to an actual transfer of the outcomes of training. Hence the question, "Does training in one field transfer to another?" should be interpreted as follows: "Does training in one field produce outcomes that function in another, thus creating an effect similar to an actual transfer of training?" This form of statement is somewhat clumsy, and hence it will be more

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[1] A more precise statement would be "increase or decrease."

'A more precise

convenient to use the simpler phrase, "transfer of training." The reader, however, should keep in mind the precise meaning of the phrase.

**Relation of transfer of training to the learning process.**—If there is transfer of training, there is nothing mysterious about it. It simply means that some of the outcomes of learning in one field facilitate or hinder learning in another field. If there is no transfer, then it follows that none of the outcomes of learning in the first field affect learning in the second field.[1] Thus the problem of the transfer of training is intimately related to that of the learning process. If the question of the transfer of training is answered affirmatively, it is necessary to consider the nature of the outcomes that facilitate or hinder learning in another field and the conditions under which they are produced. The present chapter may be thought of as supplementary to the preceding consideration of the learning process.

**Educational significance of the problem.**—The problem of the transfer of training is not merely academic. It is not possible to avoid giving some answer to it when dealing with a number of questions relating to educational practice. For example, it is necessary to reach a decision in regard to the transfer of training before one can intelligently construct a curriculum. If the curriculum maker decides that there is no transfer of training, then the curriculum should include specific provisions for training the child for each duty or task included in the objectives of the school. On the other hand, if the curriculum maker believes that training does transfer, it follows that training for certain duties will prepare him, at least in part, for performing other tasks. Consequently, it would not be necessary that the curriculum include specific provisions for training the child for each duty or task included in the objectives.

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[1] This condition may be expressed by saying that all of the outcomes of the learning process are specific and that the fields are mutually exclusive.

The teacher encounters many situations in which his belief in regard to transfer of training is a potent factor in determining his response. For example, pupils sometimes ask with reference to a topic or an entire subject, "What is the use of studying it? It does not relate to anything I expect to do." If the teacher believes that there is no transfer of training, he is frequently forced to admit that the topic has little value and consequently concludes that the text or course of study is faulty. On the other hand, the teacher who believes in transfer of training may take the position that the practical value of subject matter is unimportant and base his response to the pupil upon the disciplinary value of the subject.

**Transfer of training emphasized under faculty psychology.**—Until about 1890, it was generally believed that training did transfer and that for mental arithmetic, Latin, geometry, and formal grammar the amount of transfer was relatively large. According to the faculty psychology,[1] which was generally accepted, the outcomes of learning included trained faculties, and when a faculty, such as memory or reasoning, had been trained it would function in all situations that called for it. We no longer accept faculty psychology, and it is probably difficult for a student of educational psychology to understand the extent to which an implicit belief in the transfer of training permeated educational thinking. The Report of the Committee of Ten published in 1893 was written in terms of faculty psychology. For example, the Committee asserted:

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[1] See page 5.

> The Conferences have abundantly shown how every subject which they recommend can be made a serious subject of instruction, well fitted to train the pupil's powers of observation, expression, and reasoning.[1]
>
> Now the recommendations of the nine Conferences, if well carried out, might fairly be held to make all the main subjects taught in the secondary schools of equal rank for the purposes of admission to college or scientific school. They would all be taught consecutively and thoroughly, and would all be carried on in the same spirit; they would all be used for training the powers of observation, memory, expression, and reasoning; and they would all be good to that end, although differing among themselves in quality and substance.[2]

Other educational writings prior to 1900 include similar statements showing the widespread acceptance of faculty psychology and transfer of training. Rarely was the transfer of training questioned. Its acceptance was so firmly embedded in educational thinking that traces of it still persist.

**Faculties assumed to be trained by formal discipline.**—According to faculty psychology the transfer was effected by outcomes that were designated as "trained faculties." This hypothesis was supplemented by the belief that a faculty could be trained by a type of instruction commonly designated as "formal discipline." As this term implies, the learner was required to do a series of formal exercises which, in order to provide a basis for effective training, must be difficult. It was not considered necessary for these exercises to be interesting. In fact, some advocates of formal discipline believed the exercises were more effective if they were not interesting. Under such conditions there was an opportunity for training the will.

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[1] Report of the Committee of Ten on Secondary School Studies. New York: American Book Company, 1894, p. 43.

[2] *Ibid.*, p. 52.

The doctrine of formal discipline should be distinguished from transfer of training. The latter refers to the belief that certain outcomes of learning in one field facilitate or hinder learning in another field. The doctrine of formal discipline designates the type of instruction that was believed to be most effective in engendering these outcomes. Consequently, it is possible to repudiate the doctrine of formal discipline and still believe in the transfer of training.

**The attack upon the transfer of training and the doctrine of formal discipline.**—Although an occasional writer rejected the transfer of training and the doctrine of formal discipline, or at least disapproved of the extreme emphasis upon them, there was no effective opposition until after 1890. In this year James published the results of an experiment to determine the effect of certain training upon the ability to memorize printed material.[1] The results were not conclusive, but the experiment is notable because it represented a departure from the traditional method of dealing with the problem of the transfer of training merely by arguments based on opinion. This experimental approach and the growing interest in Herbartian psychology stimulated an attack upon the doctrine of formal discipline and the belief in transfer of training. One of the most influential events was an address by B. A. Hinsdale in 1894 before the National Education Association on the topic, "The dogma of formal discipline."[2] Although not departing very far from faculty psychology, he argued that the amount of transfer was relatively slight. He said: "No one kind of mental exercise—no few kinds—can develop the whole mind. That end can be gained only through many and varied activities."[1]

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[1] James, William.—*Principles of Psychology*, Vol. I. New York: Henry Holt and Company, 1890, pp. 666–68, footnote.

[2] Hinsdale, B. A.—*Studies in Education*. Chicago: Werner School Book Company, 1896, Chapter II.

Although many educators continued to think in terms of the doctrine of formal discipline, at least as far as transfer of training was concerned, Hinsdale's address may be taken as the turning point in the attack upon the belief in the transfer of training. Beginning about 1900, a number of psychologists attempted to remove the question from the realm of controversy by studying it scientifically.

**How investigators have endeavored to answer the question of transfer of training.**—Although it is not the purpose of the present writers to review the investigations that have been made to ascertain whether training does transfer or not,[2] it may be helpful to note the plan of two types of investigations and the difficulties encountered. A number of investigators have compared the scholastic records of students taking Latin, algebra, and other subjects supposed to have a large training value with the records of other students not taking those subjects. For example, Wilcox[3] classified 150 graduates of one high school into three groups: (1) Latin only foreign language studied; (2) German only foreign language studied; (3) No foreign language. These three groups were compared with reference to grades in English. The median grades of the first group were higher than those of the second, and those of the second were higher than those of the third. Such findings have been interpreted as showing that training in Latin did transfer to English and caused the achievements of students in this subject to be higher than it would have been if they had taken German in the place of Latin and still higher than if no foreign language had been studied.[1] Such a conclusion is not justified because information is lacking concerning the relative intelligence of the three groups. On the basis of what is known about the type of student who elects Latin and other foreign languages, it is likely that those who studied Latin were superior to those who studied German and that those who studied German were superior to those who studied no foreign language. Considering this probability we should expect the results obtained, even if there were no transfer of training from Latin to English. An investigation of this type cannot prove or disprove the transfer of training unless precautions are taken to insure the intellectual equivalence of the groups or unless allowances are made for existing differences.[2]

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[1] HINSDALE, B. A.—*Studies in Education.* Chicago: Werner School Book Company, 1896, Chapter II, p. 59.

[2] For a review of the investigations up to about 1910 see BAGLEY, W. C.—*Educational Values.* New York: The Macmillan Company, 1911, pp. 183f. A more recent review is given by WHIPPLE, G. M.—"The Transfer of Training," *The Twenty-Seventh Yearbook of the National Society for the Study of Education,* Part II. Bloomington, Illinois: Public School Publishing Company, 1928, pp. 179–203.

[3] WILCOX, M. J.—"Does the Study of High-School Latin Improve High-School English?" *School and Society,* 6:58–60, July 14, 1917.

The point made in the preceding paragraph is important. The popular belief in the transfer of training has been due largely to the observation that students who succeed in the study of Latin, geometry, and certain other school subjects also did well in English, history, and other school subjects assumed to possess little disciplinary value. Most observers, however, have overlooked the fact that probably the qualities that were responsible for success in the subjects assumed to have a high disciplinary value would make for success in other subjects also. Failure to recognize this fact has resulted in an erroneous conclusion in regard to the disciplinary value of Latin, geometry, and certain other subjects.

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[1] Wilcox did not make this interpretation.

[2] The situation is more complex and difficult than has been indicated. Under the elective system, pupils pursue different programs of study. Comparisons should not be made without considering all of the subjects studied. For an account of an investigation in which an effort was made to secure dependable comparisons see THORNDIKE, E. L.—"Mental Discipline in High-School Studies," *Journal of Educational Psychology*, 15:1–22; 83–98, January, February, 1924.

The transfer of training has been studied also by means of controlled experimentation. This procedure may be illustrated by an investigation reported by Daily.[1] His problem was to ascertain the extent to which "habits of selecting and demanding essential and adequate data for the solution of problems," engendered in connection with mathematical problems, transfer to similar problematical situations in other subjects. He used six classes in the Wadleigh High School of New York City. Two of these classes were given carefully planned instruction in solving certain problems including some in which needed data were missing and others containing superfluous data. Two other classes were given the same instruction with the addition that "the general character of the special problems was emphasized. Pupils were told that the abilities to detect the absence of missing data and to distinguish and select essential data are of importance not only in mathematics but in other subjects and outside of school."[2] The other two classes received only the regular instruction. The status of the pupils at the beginning of the experimental period was measured by the means of a series of suitable tests. A similar series was administered at the close.

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[1] Daily, B. W.—"The Ability of High School Pupils to Select Essential Data in Solving Problems," *Teachers College, Columbia University Contributions to Education*, No. 190. New York: Bureau of Publications, Columbia University, 1925. 103 pp.

[2] *Ibid.*, p. 61.

The three groups were only roughly equivalent in general intelligence and in capacity to learn mathematics, but twenty-five pupils were selected from each of the groups for interpreting the results of the experiment. In this way three closely equivalent groups were secured. Both of the groups receiving the special instruction showed distinctly greater gains in ability to deal with similar problematical situations in other subjects than the group that received only the regular instruction, and the group in which the character of the special problems was emphasized made the greatest gain. These results were interpreted as showing that the special training given in the experiment did transfer.

**Transfer of training repudiated.**—In 1916 Rugg[1] listed twenty-eight experimental investigations, the latest of which was published in 1914. Although a summary of the results of these investigations indicated that training does "transfer,"[2] many persons came to believe that the opposite had been proved. Furthermore, it had become apparent that the doctrine of formal discipline was not defensible and must be modified. Herbartian psychology[3] and Thorndike's S⇒R bond theory[4] were in distinct opposition to it. Consequently, educators swung from an implicit faith in transfer of training and formal discipline as a means of effecting this transfer to the opposite extreme, and it was widely maintained that no transfer of training was possible.[1] This radical change in psychological theory profoundly affected the curriculum. There was a persistent demand that subject matter be "practical," and that the instruction be socialized.

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[1] Rugg, H. O.—*The Experimental Determination of Mental Discipline in School Studies*. Baltimore: Warwick and York, Inc., 1916. 132 pp.

[2] "There is a distinct evidence for the so-called transference of training." *Ibid.*, p. 20.

[3] "Since all mental exercise takes its rise in definite mental content, its character is necessarily determined by its origin, so that it would be absurd to assume that thinking power developed by the study of mathematics, for instance, would as such have any validity in that, say, of biology." DeGarmo, C.—*Principles of Secondary Education*, Vol. I. New York: The Macmillan Company, 1907, p. 32.

[4] See pages 127f.

**The counter-reaction.**—The change from a confident belief in transfer of training to a repudiation of this theory was followed by a counter-reaction. Writing in 1910 Bagley stated: "The reaction against the older notion of 'formal discipline' has probably reached its extreme point and a counter-reaction seems to be setting in."[2] In his discussion of the topic this writer expresses the belief that training does transfer. In 1915 Judd published his *Psychology of High School Subjects*. In this book he vigorously attacked the critics of the transfer of training. He stated that "there is no one who denies that some kind of transfer takes place,"[3] and pointed out that the real question at issue is the degree of transfer and not whether any transfer occurs.

**The present belief in regard to transfer of training.**—Although it is not uncommon to hear teachers and other persons who should be informed express the belief that there is no transfer of training, psychologists now generally agree that training is not entirely specific in its results and hence does transfer. This statement, however, needs to be qualified in certain respects. In the first place, it is recognized that the amount of transfer varies, usually being small. It may be negative. The second point to be noted is that the amount of transfer is not determined solely by the subject studied, but is influenced to a significant extent by the method and spirit of the instruction. Transfer is not certain. There *may* be transfer in the case of a particular pupil or there may not be.

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[1] Very few, if any of the competent psychologists ever repudiated entirely the theory of the transfer of training, but statements by certain psychologists were interpreted to mean that they had done so.

[2] Bagley, W. C.—*Educational Values.* New York: The Macmillan Company, 1911, p. 180.

[3] Judd, C. H.—*Psychology of High School Subjects.* Boston: Ginn and Company, 1915, p. 404.

These dogmatic statements will be better understood after reading the following discussion. It may be noted here, however, that our present belief in the transfer of training does not involve a return to faculty psychology. We no longer speak of the training of faculties such as memory, observation, and the like. Instead we now conceive of the transfer of training in terms of our present psychology. Consequently when there is transfer of training, it is effected through the three types of outcomes of learning—specific habits, knowledge, and general patterns of conduct.

**The meaning of mental development.**—We speak of physical development, meaning thereby the development of bones, muscles, and vital organs. This development is partly a natural growth and partly the result of appropriate food and exercise, and freedom from disease. A person who is well-developed physically is equipped to engage in various types of manual labor. In other words, he possesses organic power.

We also speak of mental development and frequently there is an implication that it represents something similar to physical development. This is not true. Mental development, if it means anything, merely refers to a person's general intellectual status, which may be described as the composite of his intelligence and his achievement.[1] Strictly speaking, there is no such thing as a trained mind unless the phrase is interpreted in this sense. In other words, psychologists do not now conceive of the mind as consisting of certain faculties or processes which may be developed and strengthened as is possible in the case of the muscles.

**Explanations of the transfer of training.**—Thorndike has proposed the explanation that transfer is effected through identity of substance or of procedure.[2] "One mental function or activity improves others in so far as and because they are in part identical with it, because it contains elements common to them." There is identity of substance or content in arithmetic and algebra; that is, a number of the specific habit and knowledge S→R connections learned in arithmetic are useful in learning algebra. Likewise there is identity of substance in English literature and history, in physics and chemistry, in Latin and French, in Latin grammar and English grammar. On the other hand, there is little or no identity of substance in Latin and typewriting, in physics and stenography, in American history and algebra.

Identity of procedure refers to general patterns of conduct rather than to specific habits or knowledge. "Earning one's living for three months may make an improvement in self-reliance in general, for the feelings 'I can do something, I have succeeded, I am not an incompetent' awakened by self-support are one feature of self-reliance in general."[3] If a general pattern engendered in one subject is useful in the study of another, there is identity of procedure. Such general patterns as accuracy, neatness, persistence, self-reliance, and the like, function in the learning of most school subjects. Identity of procedure affords a widely applicable explanation of the transfer of training.

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[1] Achievement includes general patterns of conduct.

[2] Thorndike, E. L.—*The Principles of Teaching.* New York: A. G. Seiler, 1906, p. 243.

[3] *Ibid.*, p. 245.

Judd[1] has emphasized the explanation that the apparent transfer of training is due to the process of generalizing. In connection with his learning in one field, such as solving arithmetical problems, the pupil verifies a proposed plan of solution by testing it for consistency with the conditions of the problem and any rules that he may be able to recall. He finds that this procedure is helpful in dealing with arithmetical problems. If he then generalizes by recognizing its value as a procedure in verifying answers to thought questions in history, transfer of training takes place. This explanation makes the transfer depend upon the process of generalizing. If the pupil generalizes, there is transfer; if he does not, there is no transfer. In support of this explanation, Judd points out that "one and the same subject matter may be employed with one and the same student with wholly different effects, according to the mode of presentation. If the lesson is presented in one fashion it will produce a very large transfer; whereas if it is presented in an entirely different fashion it will be utterly barren of results for other phases of mental life."[2]

This explanation is very similar to that offered by Thorndike's identity of procedure. The principal difference is the point of view. Thorndike calls attention to the type of S→R connections by which the transfer is effected. Judd points out the learning process by which the S→R connections are acquired.

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[1] JUDD, C. H.—*Psychology of High-School Subjects.* Boston: Ginn and Company, 1915, Chapter XVII.

[2] *Ibid.*, p. 412. (By permission of Ginn and Company.)

Freeman has offered the "development of attitudes" as an explanation of the transfer of training.[1] This is essentially included in the explanation proposed by Judd. In fact, both explanations might be expressed by saying that transfer of training is effected by engendering certain general patterns of conduct that will function in a variety of situations.

Bagley[2] emphasizes "conscious effort" on the part of the learner as an essential factor in the process of generalization. He reviews certain experimental evidence and then concludes: "In all of these experimental investigations, then, it is the factor of conscious transfer that stands out sharp and clear as the determining agent in whatever 'spread' of the results of training may be detected."[3]

These explanations are more nearly in agreement than may first appear. Different terminology is used, but the principal difference appears to be the point of emphasis. Thorndike calls attention to the types of S→R connections by which the transfer is effected. Judd, Freeman, and Bagley attempt to explain the learning process by which the S→R connections are acquired. Consequently, transfer of training does not involve the controversial issues that are implied in some writings, especially Judd's chapter, to which reference was made on page 237. The reader, however, should not infer that all of the questions concerning transfer of training have been answered. According to Henmon "we have not settled the quarrels about disciplinary values or transfer, nor is there any prospect of our doing so."[1] This statement represents an extremely critical view and the teacher does not need to be concerned with many of the unanswered questions.

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[1] FREEMAN, F. N.—*How Children Learn.* Boston: Houghton Mifflin Company, 1917, pp. 274f.

[2] BAGLEY, W. C.—*Educational Values.* New York: The Macmillan Company, 1911, pp. 193f.

[3] *Ibid.*, pp. 200.

**Transfer in terms of S→R bonds.**—If the hypothesis that the outcomes of learning may be described in terms of S→R bonds is correct, it follows that the appearance of transfer is due to certain S→R bonds, included in the outcomes resulting from the study of the subject in question, functioning in the learning in the field of another subject. For example, if Latin has a disciplinary value, then the outcomes resulting from the study of this subject include certain S→R bonds that function in the learning of another subject, such as English or history. In Chapter IV three types of controls of conduct were recognized—specific habits, knowledge, and general patterns of conduct. Each of these types was described in terms of characteristic S→R bonds. Hence in endeavoring to understand how training appears to transfer, it should be helpful to examine the outcomes resulting from the study of a given subject or topic and note those that may function in learning in another field.

**Transfer by means of specific habits.**—The acquisition of a specific S→R connection may facilitate the learning of a related one. Experimental evidence indicates that $6 \times 7 = 42$ and $7 \times 6 = 42$ represent two S→R connections rather than a single one. Likewise $6 \times 5 = 30$ and $6 \times 6 = 36$ are different. It appears that knowing $6 \times 7 = 42$ facilitates the learning of $7 \times 6 = 42$ and that knowing

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[1] Henmon, V. A. C.—"Measurement and Experimentation in Educational Methods," *Journal of Educational Research*, 18:185–94, October, 1928.

$6 \times 5 = 30$ facilitates the learning of $6 \times 6 = 36$.[1] Knowing the addition combinations facilitates the learning of the subtraction combinations.

The presence of certain specific habits may interfere with the learning of others. Thorndike[2] cites the case of forming the habit of writing down the sum in single column addition when this sum is over 9. This habit interferes with learning to add numbers of two or more places. In general the presence of a specific habit contrary to the one desired interferes with the learning.

**Transfer by means of knowledge.**—Useful knowledge does not consist of isolated ideas, facts, and principles. Instead it is characterized by a multiplicity of connections.[3] It affords a means of responding to "new" situations. When a person makes a response to a "new" situation, there is a type of transfer. Furthermore, the different school subjects do not represent isolated fields of learning. There is much overlapping, providing frequent opportunities to apply knowledge acquired in another field. For example, the student of English literature has numerous occasions to apply knowledge from other fields, especially geography and history. The student may fail to make the application because the knowledge acquired is not of the useful type, that is, because the connections are lacking in number and probably in strength. However, the opportunity for this type of transfer exists.

Here, also, the transfer is by means of "identity of substance."

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[1] Facilitation in learning number combinations is recognized by THORNDIKE, E. L.—*Psychology of Arithmetic.* New York: The Macmillan Company, 1922, pp. 143f.

[2] *Ibid.*, p. 144.

[3] See pages 134–35.

**Transfer by means of general patterns of conduct.**—Transfer by means of general patterns of conduct is of a different type. If a student acquires a critical attitude from the study of Latin, and if it is sufficiently generalized, there will be transfer to other subjects in which a critical attitude is a useful procedure. Similarly, if a student acquires a problem-solving attitude from the study of arithmetic, and if it is sufficiently generalized, there will be transfer to other subjects. If a student forms the ideal of overcoming obstacles by his own efforts, and if the general pattern is sufficiently generalized, there will be transfer. The reader should note that in each of these statements there are two "if's." As pointed out on page 185, the learning process in acquiring general patterns is a subtle one, and one student may acquire a pattern while his classmate fails to do so. Furthermore, a general pattern may exist in various degrees of generalization. Transfer by means of general patterns from one subject to another is by no means certain; it may occur or it may not.

This type of transfer is by means of "identity of procedure."

**The relation of general intelligence to transfer of training.**—In so far as general intelligence is affected by training,[1] such training transfers to other fields, but one may ask whether the transfer is likely to be greater in the case of bright children than in the case of those on the lower levels of intelligence. Other things being equal bright children learn more. They are more likely to generalize. Consequently we should expect the amount of transfer to be greater.

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[1] See pages 255f.

**Negative transfer or interference.**—Although the reader's attention has been called to negative transfer or interference, this idea has not been sufficiently emphasized in the preceding discussion. It is a well-known fact that the presence of one set of specific habits may interfere with the formation of another set. A person who has become accustomed to driving a car with a standard gear shift usually experiences difficulty in learning to drive one with a different gear shift. An habituated error in spelling may interfere with learning the correct spelling. However, interference, like positive transfer, is by no means certain.[1]

**Transfer in terms of neural action.**—If one considers the neural action involved in human responses to stimuli[2] and the neural changes that occur in learning,[3] it is apparent that when transfer occurs a neural tract which has been exercised in one field of learning must be stimulated in the course of the learning in the second field. This does not appear impossible. Presumably the neural tract that is involved in giving the response 42 to the stimulus 6 × 7 = ? overlaps or is closely connected with the neural tract that is involved in giving the response 42 to the stimulus 7 × 6 = ? Hence it appears reasonable that learning the response to the first stimulus will facilitate connecting the response to the second stimulus.

By definition a general pattern response is one that is made to a variety of situations, or more accurately to an element common to a variety of situations,[4] the range of situations depending upon the degree of generalization effected. This is equivalent to saying that the neural tract whose stimulation produces the mental process designated as a reaction tendency may be aroused to action by a variety of situations. For example, a person learns to make the attention response[1] to questions asked in the Latin class. This involves a degree of generalization, and hence a type of transfer, because each question is a different stimulus.[2] A larger degree of transfer is effected when the attention response is made to questions asked in other classes.

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[1] See Pyle, W. H.—*The Psychology of Learning.* Baltimore: Warwick and York, Inc., 1921, pp. 239–42.

[2] See pages 114f.

[3] See pages 148f.

[4] See pages 138f.

In the case of negative transfer or interference, the first learning has resulted in the establishment of certain S→R connections (neural pathways) which tend to drain off the nerve impulses and hence interfere with the establishment of new neural pathways. For example, the neural pathways established in operating a standard gear shift interfere with learning to operate another type of gear shift because they tend to drain off the nerve impulses.

**Amount of transfer influenced by type of training.**—The explanation of transfer in terms of "identity of procedure" implies that the amount of transfer will be greater when the learner's attention is directed to the procedure. For example, memorizing poems, prose, dates, vocabulary of a foreign language, and the like is accomplished most efficiently when certain procedures are followed.[3] Hence if training in memorizing one type of material transfers to memorizing another type by means of identity of procedure, it seems plausible that the amount of transfer would be greater when the learner's attention is directed to the procedure. Woodrow[1] has reported a study that definitely supports this hypothesis. One experimental group practiced memorizing poetry and nonsense syllables but no instructions were given in regard to the method these pupils were to follow except that they "were told to memorize by heart and when they finished one selection to begin another." A second experimental group spent more than two-fifths of the time devoted to training in listening to "an exposition of the technique of memorizing, including rules and illustrations of how these rules should be applied." Although the training period, which was the same for both groups, was relatively short (177 minutes), the transfer was distinctly greater in the case of the second group.

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[1] See page 102.

[2] All questions have at least one element in common. This is indicated by the common noun "question."

[3] See page 165.

The results of this investigation are in agreement with conclusions reached by other investigators.[2] There is considerable evidence for the statement that the method and spirit of the instruction are dominant factors in determining the amount of transfer. If this conclusion is true it seems to explain why the study of certain school subjects such as Latin, geometry, and mental arithmetic has appeared to result in relatively large amounts of transfer. During the relatively long period that these subjects have been taught in our schools, the methods of teaching evolved, especially by certain teachers, may be suitable for engendering general patterns of conduct that function in other fields. On the other hand, the methods of teaching the newer subjects whose content is still being formulated and organized may not be as favorable to the engendering of such general patterns of conduct.

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[1] WOODROW, HERBERT.—"The Effect of Type of Training upon Transference," *Journal of Educational Psychology*, 18:159–72, March, 1927.

[2] For example, see the statement by Bagley quoted on page 238.

**The efficiency of transfer.**—Granting the possibility of transfer, there remains the question of the educational efficiency of the process. For example, the transfer of training from Latin to other subjects is valuable, but does the ratio of the amount of transfer plus the intrinsic value of the total outcomes resulting from the study of Latin to the time and energy spent in the study of the subject represent educational efficiency? Obviously any transfer that takes place adds to the efficiency of the learning process, but if the value of the direct outcomes is small and the transfer uncertain, then one may properly ask whether the time and the energy spent in the study of Latin have been expended wisely. Advocates of Latin as a school subject insist that the expenditure is efficient, that is, that the ratio of the transfer plus the intrinsic worth of the direct outcomes to the time and the energy expended is high. Those who oppose the teaching of Latin, especially as a required subject, maintain that the ratio is very low. They insist that controls of conduct that make possible transfer by identity of substance can be acquired more efficiently by including them in the objectives of the subject to which transfer is made. For example, the study of Latin has helped many persons in understanding English words derived from the Latin, but some authorities point out that the controls of conduct by which this transfer was effected could have been acquired in much less time by expanding the course in English so as to include the study of root words.

When there is identity of content between two subjects it is obvious that the study of one of them will result in outcomes that will function as factors in determining the pupil's responses to learning exercises in the other. The amount of "transfer" will vary with the degree of identity in content. If one subject is a prerequisite for the other as in the case of first-year algebra and advanced algebra, there is a high degree of identity and there will be a large amount of transfer. When there is little or no identity of content, as in the case of Latin and typewriting, there can be no transfer by this means.[1]

There are many opportunities for transfer by means of identity of procedure, but as pointed out on page 241 the transfer is dependent upon conditions that are difficult to control. In general, the efficiency of transfer appears to be low instead of high. After reviewing the experimental evidence Starch stated that in the case of closely allied mental functions the amount of transfer "is probably in the neighborhood" of 20 per cent to 30 per cent. For more unlike functions it ranges from this point to zero.[2]

**The disciplinary value of school subjects.**—This paragraph heading implies the question, "What amount of transfer results from training in the several school subjects?"[3] In view of the variations in the transfer of training we should expect to find that in the case of a particular school subject, the amount of transfer will not be the same for all pupils or for all methods of teaching. However, we may consider the disciplinary value of school subjects in terms of their average or typical effect upon pupils.

As pointed out in the beginning of this chapter, there has been, until relatively recently, a profound faith in the disciplinary value of certain school subjects—Latin, mental arithmetic, grammar, algebra, and plane geometry. This faith is still held by a surprisingly large number of persons. A striking demonstration of the present attitude is furnished by the assemblage of opinions in regard to the value of the classics presented at a conference held at Princeton University, June 1, 1917. These opinions were from "nearly three hundred competent observers representing the leading interests of modern life, and including many of the highest names in our land." "Their testimony, with occasional variation in degree of conviction or of emphasis on one or another factor, converges steadily to one main conclusion; namely, that experience proves the classics of essential value in our American liberal education."[1]

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[1] Learning where there is little or no chance for "transfer" hasb een called "sheer modifiability." An illustration is learning to draw lines of a specified length when blindfolded. See THORNDIKE, E. L., and others.—*Adult Learning.* New York: The Macmillan Company, 1928, pp. 97f.

[2] STARCH, DANIEL.—*Educational Psychology.* New York: The Macmillan Company, 1927, p. 242. The reader who is interested in the experimental evidence should consult pages 220–41.

[3] For an interesting and stimulating theoretical discussion of this question see BAGLEY, *op. cit.*, pp. 201f.

Evidence of a similar belief in the disciplinary value of a number of other school subjects could doubtless be assembled, but assemblages of opinion do not constitute proof of disciplinary values. Neither can they be used to determine the relative disciplinary values of different subjects. This determination requires experimental methods. Thorndike[2] attempted to determine the relative disciplinary values of a number of high-school subjects by having a test given in certain high schools in May, 1922, and again in May, 1923. The test consisted of a composite of fifteen tests, and was considered to measure "those intellectual abilities which the studies of alleged general benefit to the intellect are most likely to improve." The pupils to whom these tests were administered pursued a variety of programs of study during the year intervening between the two testing dates. Consequently an opportunity was afforded for comparing the disciplinary effect of different school subjects. The statistical methods employed in making the comparisons are intricate and need not be described here. Although Thorndike points out that the experiment should be repeated with a larger number of pupils before the conclusions are accepted as final, it appears that the disciplinary value of the different studies is small, and that the differences in disciplinary value are so small that the values of studies may be decided largely by consideration of the special training which they give. "The expectation of any large differences in general improvement of the mind from one study rather than another seems doomed to disappointment. The chief reason why good thinkers seem superficially to have been made such by having taken certain school studies, is that good thinkers have taken such studies, becoming better by the inherent tendency of the good to gain more than the poor from any study. When the good thinkers studied Greek and Latin, these studies seemed to make good thinking. Now that the good thinkers study physics and trigonometry, these seem to make good thinkers. If the abler pupils should all study physical education and dramatic art, these subjects would seem to make good thinkers."[1]

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[1] These quotations are from a circular advertising the report of the Princeton Conference on Classical Studies.

[2] THORNDIKE, E. L.—"Mental Discipline in High-School Studies," *Journal of Educational Psychology*, 15:1–22, 83–98, January, February, 1924.

The findings of this study seem to corroborate the thesis that the amount of transfer depends upon the methods of teaching.[2] It is not unlikely that the nature of the content of a study and its organization affect the

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[1] Thorndike, E. L.—"Mental Discipline in High-School Studies," *Journal of Educational Psychology*, p. 98.

[2] See pages 237, 244.

"general improvement of the mind" to some extent, but in the light of our present knowledge of the disciplinary value of school subjects it appears that the methods of teaching employed and the standards of attainment insisted upon are much more potent influences.[1]

**The disciplinary value of the project method.**—According to the doctrine of formal discipline, the "development of the mind" could be accomplished best by a course of definitely prescribed exercises. Furthermore, many authorities insisted that the learning exercises should be difficult. Some took the position that the effect of doing the exercises tended to be inversely proportional to the pupil's interest in them. Recently the opposite thesis has been advocated, especially by proponents of the project method. According to them, "development of the mind" is more likely to occur when the pupil is engaged in realizing his purposes, satisfying his needs, or solving problems that have arisen in the course of his activities.

Although the claims of the project-method enthusiasts seem to be somewhat exaggerated, it is now generally agreed that mere difficulty does not increase the educative value of an exercise. Neither is lack of interest on the part of the pupil an asset. "It is absurd to suppose that a child gets more intellectual or mental discipline when he goes at a matter unwillingly than when he goes at it out of the fullness of his heart."[2]

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[1] Although consideration of methods of teaching is beyond the scope of this text, the reader will probably find it helpful to read Chapter X, "Directing the Acquisition of General Patterns of Conduct" in MONROE, WALTER S.—*Directing Learning in the High School.* Garden City: Doubleday, Doran and Company, Inc., 1927.

[2] DEWEY, JOHN.—*Interest and Effort in Education.* Boston: Houghton Mifflin Company, 1913, pp. 1–2.

## LEARNING EXERCISES FOR THE READER

Talbott ✓ 1. Distinguish between the doctrine of formal discipline and transfer of training. Show why a person may repudiate the former and still believe in the latter.

✓ 2. Is faculty psychology essential for transfer of training? Why?

Wilske 3. Give from your own experience five illustrations of training that transferred. Was the transfer due to the nature of the subject studied or to the methods of teaching?

Greer 4. How do you account for the fact that many persons claim that the study of Latin results in a large amount of transfer? See page 247.

5. Read Judd.—*Psychology of High School Subjects*, Chapter XVII. Does it appear that Judd is begging the question in this discussion? Give your reasons.

Tate ✓ 6. In the light of the point of view expressed in the preceding pages, what reply should a teacher make to the pupil who asks what is the use of studying Latin, geometry, or some other subject that seems to him not to be practical?

Hedrick 7. Give five examples of transfer through identity of substance.

Staiger 8. Give five examples of transfer through identity of procedure.

9. Discuss each of the following propositions:

   a. There can be no transfer from a given training situation of something that is not developed in that training.

   b. Undesirable traits developed in a given training situation may transfer to other situations.

   c. If certain desirable traits can be developed more successfully by the pursuit of a given subject than by any other means, the pursuit of that subject is thereby justified on the grounds of its transfer values.

   d. Although the amount of transfer from a given subject may be relatively small, say 5 per cent., the pursuit of that subject may be justified provided the transfer is over a wide range—that is, provided it applies to a large number of different types of situations.

   e. The student who does a poor, or even mediocre, quality of work in a given subject is not likely to obtain worthwhile transfer values from the pursuit of that subject even though the possibility of such values is great.

f. The transfer values of a given subject, as it is ordinarily taught and learned, may be vastly inferior to the possible transfer values of that subject.

10. Prepare a paper on "transfer of training" that would be suitable for reading at a parent-teacher meeting.

11. In choosing electives, should a student consider the instructor as well as the nature of the subject? Give your reasons. ✓

12. Prepare a discussion of the disciplinary value of the project method. Develops, community interest, responsibility + initiative, coöperation. Rational + practical learning.

Thorndike } what they believe
Judd } transfer of training.

Josephine Taylor

# CHAPTER VIII

## INTELLIGENCE AND ITS MEASUREMENT

**The problem of this chapter.**—We employ such words as cheerful, morose, phlegmatic, vivacious, stubborn, ingenious, vacillating, reliable, intelligent, and stupid to designate traits of human beings that are influential factors in determining their behavior. The central problems of this chapter are to consider the nature of the trait or combination of traits commonly designated as "intelligence" or "intellect," and the means for measuring it.

**The meaning of intelligence.**—When used as a technical term, "intelligence" refers to a person's ability to engage in certain types of activities.[1] These types of activities have been described in various ways. Burt has described them as those involved in making readjustments to "relatively novel situations."[2] Stern called them conscious adjustments of thinking to new requirements.[3] Terman has referred to them as "abstract thinking."[4] Colvin preferred to call them "learning activities."[1] Thorndike has defined them as "good responses from the point of view of truth or fact."[2] Careful examination of the statements of these writers and of a number of other authorities suggests that for practical school purposes we are justified in defining intelligence as *capacity to engage in the learning activities of the school in such a way that the process of learning is efficient.*[3]

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[1] The reader's attention is called to the qualifying clause in this sentence. "Intelligence" and more frequently "intelligent" are used with the meaning of "being informed" or "showing knowledge or understanding." Hence according to this meaning an intelligent person is one who is informed. This meaning may be designated as "popular" to distinguish it from the "technical" meaning with which we are concerned in this chapter.

[2] BURT, C.—"Experimental Tests of General Intelligence," *British Journal of Psychology*, 3:168, December, 1909.

[3] STERN, W.—*The Psychological Methods of Testing Intelligence.* Baltimore: Warwick and York, Inc., 1914, p. 3. Translated by G. M. Whipple.

[4] TERMAN, L. M.—"Intelligence and Its Measurement: A Symposium," *Journal of Educational Psychology*, 12:128, March, 1921.

This definition is general and incomplete. "Capacity" is not defined. Does it mean "capacity to engage in harder and harder tasks," or "capacity to do quickly tasks of a given difficulty," or "capacity to do a large number of tasks"? These possible meanings of "capacity" suggest that intelligence has three dimensions or characteristics. Assuming that intelligence may be measured by a test consisting of a series of groups of exercises, the exercises of any group being equal in difficulty and the groups forming a scale of increasing difficulty, these dimensions may be described as follows: (1) the highest level of difficulty on which a given per cent of correct responses is attained, the time for the test being unlimited; (2) the number of exercises on a given level of difficulty done correctly within a specified time limit; (3) the total number of exercises done correctly, the time for the test being unlimited. Thorndike[1] calls these dimensions *altitude*, *speed*, and *area* respectively. Although there is seldom any specification, the structure of our present intelligence tests implies that we measure primarily the *altitude* of intelligence[2] which may be loosely defined as "capacity to do harder and harder intellectual tasks."

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[1] Colvin, S. S.—"Principles Underlying the Construction and Use of Intelligence Tests," *Twenty-First Yearbook of the National Society for the Study of Education*, Part I. Bloomington, Illinois: Public School Publishing Company, 1922, p. 17.

[2] Thorndike, E. L.—"Intelligence and Its Measurement: A Symposium," *Journal of Educational Psychology*, 12:124, March, 1921. See pages 127–47, 195–216, for statements by other psychologists.

[3] In accepting this definition the reader should bear in mind that a child's success in learning is affected by other traits—such as interest, determination, and perseverance—and by his physical condition, acquired study habits, prerequisite achievement, and the like. For a further discussion of this point, see pages 220f.

We may add to our understanding of intelligence by considering the nature of the intellectual tasks or exercises to be used in securing a measure of this trait. Examination of intelligence tests reveals two general classes of exercises: (1) those requiring reasoning or the higher mental processes, and (2) those calling for association or the lower mental processes. The former are illustrated by arithmetical problems, and the latter by exercises that ask for synonyms. With reference to the relative merits of these two types of exercises, Thorndike has proposed a hypothesis which he epitomizes in these words: ". . . by original nature, the intellect capable of the highest reasoning and adaptability differs from the intellect of an imbecile only in the capacity for having more connections of the sort described."[3] These "connections" are described as "whatever anatomical and physiological fact corresponds to the possibility of forming one connection or association or bond between an idea or any part or aspect or feature thereof and a sequent idea or movement or any part or aspect or feature thereof."[4] Hence his

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[1] Thorndike, E. L., and others.—*The Measurement of Intelligence.* New York: Bureau of Publications, Teachers College, Columbia University, 1925, pp. 24f.

[2] *Ibid.*, p. 404.

[3] Thorndike and others, *op. cit.*, pp. 421–22. See pp. 422f. for the experimental verification of this hypothesis.

[4] *Ibid.*, p. 415.

Butler

hypothesis is that the quality of "intellect" depends upon the number of connections, and the quality or amount of a person's intelligence at a given time is simply the number of usable connections he has formed.

If the quality of intellect depends upon the number of usable connections, it follows that intelligence may be measured by means of tests of the association type. This is essentially equivalent to saying that if certain precautions are taken a general-information test may be used to measure intelligence, and that it is not necessary to employ tests that call for the higher mental processes. This statement is subject to certain qualifications, which can be more easily understood when we consider the assumptions underlying intelligence tests.[1]

**Thorndike's CAVD definition of intelligence.**—In an attempt to formulate a precise definition of intelligence Thorndike[2] has restricted it to the capacity to do four types of exercises: (1) completion, (2) arithmetical problems, (3) vocabulary, and (4) directions to be read. The capacity to do exercises of these types he calls a "segment of intelligence" and designates it as "CAVD intellect." By using this phraseology, Thorndike implies that more than these four types of exercises may be needed to secure complete measures of intelligence and hence that if we wish to be precise in speaking of measures of intelligence we should specify the types of exercises used.

**Nature versus nurture as a determinant of intelligence.**—A number of psychologists, of whom Terman has been most prominent, have insisted that a child's capacity to

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[1] See pages 278f.

[2] Thorndike, E. L., and others.—*The Measurement of Intelligence.* New York: Bureau of Publications, Teachers College, Columbia University, 1925, p. 65.

criticize

learn is a native trait, or a phase of his nature, and hence can be affected relatively little or not at all by the training that he receives. Other authorities, notably Bagley, have maintained that a child's intelligence is affected by environmental factors, of which school training is the most potent, to such an extent that we are not justified in considering intelligence an unchangeable human trait.

In order to think clearly about the relative contributions of nature and nurture to a child's intelligence at any stage of his development, the reader should keep certain facts in mind. In the first place, we are able to know a child's intelligence only through his behavior. There is no known means of ascertaining the degree of intelligence a child possesses at a given age except by measuring certain items of his behavior or responses to stimuli. The phrenologists proposed that certain traits related to intelligence could be estimated by noting certain details of the shape of a person's head; but it is now generally agreed that this method is not valid. In the second place, the reader should keep in mind that a child's responses are not determined entirely by what we call intelligence. This point has been treated in Chapter VI[1] and need not be elaborated here. A third fact is that when the word "intelligence" is used in a quantitative sense—that is, when it refers to the degree or amount of this trait—it means "intelligence as measured by a test." If a writer or speaker were precise in his statements, he would say "intelligence as measured by a particular test" instead of merely "intelligence." Finally, measures of intelligence, even those yielded by our best tests, are not as accurate as physical measurements—such as those of height, weight, and the like. Since the topic of the measurement of intelligence will be considered later (see pages 264f.), this fact is stated dogmatically here; but the reader should bear in mind that apparent exceptions to a generalization relative to the effect of training upon intelligence as measured by a particular test may be due in part, or even wholly, to errors in the measurements.

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[1] See pages 220f.

✓ The preceding paragraph implies the belief of the present writers that much of the controversial discussion in regard to the influence of nurture upon intelligence is due to the failure to distinguish between the theoretical concept of intelligence and intelligence as measured by a particular test. It appears that frequently the word "intelligence" has been used by a writer or speaker to designate the theoretical concept, but has been interpreted by his readers or listeners to mean "as measured by some intelligence test." In the following discussion of "nature versus nurture" and in the summary of the experimental evidence the word "intelligence" is used to represent the theoretical concept. When the second meaning is intended, the phrase "intelligence as measured" will be used.

**The Terman-Bagley controversy.**—The opposing beliefs concerning the relative influence of nature and nurture upon intelligence have been advocated by Terman and Bagley. The former has maintained that intelligence is essentially a native trait, which is relatively unaffected by school training or other environmental factors, and that, given a child's I.Q.,[1] the limits of his educability can be predicted "fairly accurately."[2] Bagley and others have characterized this belief as "educational determinism" and have insisted that intelligence is affected by schooling and other environmental factors.[1] The difference between Terman's "relatively unaffected" and the environmentalists' claim probably has not been as great as the controversial discussions have suggested to the casual reader. It is beginning to appear that both sides mean about the same thing with reference to the relative influence of nature and nurture upon intelligence, but they still differ in regard to the practical application.

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[1] I. Q. is to be read "intelligence quotient." It is the quotient obtained by dividing mental age, which is derived from the test score, by the person's chronological age. See page 268 for further discussion.

[2] Terman, L. M.—*The Intelligence of School Children.* Boston: Houghton Mifflin Company, 1919, pp. 268–69.

**The experimental evidence.**—The more important studies of the relative influence of nature and nurture upon intelligence are to be found in Part I of the *Twenty-Seventh Yearbook of the National Society for the Study of Education.* Of this group those commonly referred to as the Chicago[2] and the Stanford[3] studies are the most pretentious and the most scientific. Both of these studies are too complex and extensive to be reviewed here,[4] and consequently the description will be limited to a few general statements. Foster children were used as subjects in both studies. The general plan was to secure measures of the intelligence of these children at the time of placement in homes and a second measurement after a lapse of several years. The quality of the homes was also measured. From the data obtained by these methods[1] the effect of home environment upon "intelligence as measured" was computed. Both studies show that the environment did affect the I.Q. of these children, good homes increasing it and poor homes depressing it. In the Chicago study, the average I.Q. of the group of foster children in better homes increased approximately 10 points (95.2 to 105.6),[2] while the average I.Q. of the group in poorer homes increased only 5 points. The Stanford study showed somewhat less differences but the investigator concludes:

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[1] Bagley, W. C.—*Determinism in Education.* Baltimore: Warwick and York, Inc., 1925. 194 pp.

[2] Freeman, F. N., and others.—"The Influence of Environment on the Intelligence, School Achievement, and Conduct of Foster Children." *Twenty-Seventh Yearbook of the National Society for the Study of Education*, Part I. Bloomington: Public School Publishing Company, 1928, pp. 103–217.

[3] Burks, B. S.—"The Relative Influence of Nature and Nurture Upon Mental Development; A Comparative Study of Foster Parent-Foster Child Resemblance and True Parent-True Child Resemblance." *Twenty-Seventh Yearbook of the National Society for the Study of Education.* Part I. Bloomington: Public School Publishing Company, 1928, pp. 219–316.

[4] A brief description is given on page 362.

> The maximal contribution of the *best* home environment to intelligence is apparently about 20 I.Q. points, or less, and almost surely lies between 10 and 30 points. Conversely, the least cultured, least stimulating kind of American home environment may depress the I.Q. as much as 20 I.Q. points. But situations as extreme as either of these probably occur only once or twice in a thousand times in American communities.[3]

In another statement this writer says: "Nearly 70 per cent of school children have an actual I.Q. within 6 to 9 points of that represented by their innate intelligence."[4]

In commenting upon the yearbook, Freeman states: "The preponderance of evidence appears to me to indicate beyond a doubt that the scores on intelligence tests—and hence intelligence, so far as we can now measure it—are influenced to a marked degree by the character of the home and the other circumstances which go with it."[1]

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[1] The statements made here do not adequately describe the methods of collecting data, especially in the Stanford study in which a control group was used.

[2] This includes a correction for faulty standardization of the test used.

[3] Burks, *op. cit.*, p. 309.

[4] *Ibid.*, p. 308.

**The interpretation of the experimental evidence.**—The findings reported in Part I of the *Twenty-Seventh Yearbook* appear to be interpreted by both parties of the nature–nurture controversy as supporting their respective positions. Terman, who has been the leader of the "so-called hereditarian" group, appears to interpret the findings as supporting his belief that the I.Q. is relatively constant.[2] Judd, on the other hand, appears to believe that the findings support the contentions of the environmentalists.[3] This difference in interpretation probably indicates that each group has failed to understand clearly and accurately the position of the other.

In arriving at his own interpretation of the experimental evidence, the reader should bear in mind that the investigations referred to here relate to the influence on the I.Q. of "home environment" of which the school was only one factor, and hence that these investigations do not show what the school alone is doing, and especially what it might do to increase "intelligence as measured." The learning activities of school children, and hence their achievements, depend upon several factors,[4] of which intelligence as we measure it is only one. Granting that the school can effect only very slight increases in the I.Q.'s of its pupils, it does not follow that improved methods of teaching and of school organization may not produce marked increases in achievement.[1] The available facts justify the belief that the teacher should approach his task with the conviction that, although a child's nature will limit his achievements, the teacher's efforts do count, and achievements under good teaching will be materially higher than under poor teaching. It is true that the findings of some investigators appear to discredit this position, but these studies have dealt with school conditions as they are, and hence have not revealed what would occur under improved conditions. Consequently we must exercise caution in interpreting the results of nature–nurture investigations. In this connection it is significant to note that Thorndike's hypothesis referred to on page 254 credits the quantity or amount of a person's intelligence "largely to his training."[2] Original nature supplies the possibility of learning or of the operation of training. The connections formed are the result of training.

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[1] Freeman, F. N.—"An Evaluation of the Evidence in Part I of the Yearbook and Its Bearing on the Interpretation of Intelligence Tests," *Journal of Educational Psychology*, 19:380, September, 1928.

[2] Terman, L. M.—"Reply to Criticisms of Part I, and Introducing Part II of the 1928 Yearbook of the National Society for the Study of Education," *Journal of Educational Psychology*, 19:369–73, September, 1928.

[3] Judd, C. H.—"Intelligence as a Method of Adaptation," *Journal of Educational Psychology*, 19:397–404, September, 1928.

[4] See pages 220f.

**General versus specific intelligence.**—Spearman, an English psychologist, and his co-workers have advocated a "two-factor" theory of intelligence.[3] One of these factors is general and remains constant for a given child; the other is specific and is different for different situations. Thus a pupil's capacity to learn in arithmetic is a combination of a general factor, "g," and a specific factor, "s," that is peculiar to arithmetic; in geography his capacity to learn is a combination of the same "g" factor and the "s" factor for geography. It is obvious that this "two-factor" theory provides an explanation for the pupil who does well in certain school subjects but fails in others. Thorndike[1] has proposed the theory that what we call intelligence is a composite of a large number of abilities, the nature of this composition varying from child to child. This is not the place to consider the merits of these two theories,[2] but it may be noted that the content of our intelligence tests is in accord with the theory proposed by Thorndike. In securing a measure of general intelligence we use exercises from several fields and hence measure a number of abilities. A pupil's score on a test represents an "average" of the abilities measured, or more precisely it represents an "average" of certain samples of his intelligence.

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[1] For an elaboration of this point, see Gates, A. I.—"Observed Facts and Theoretical Concepts," *Journal of Educational Psychology*, 19:381–88, September, 1928.

Part II of the *Twenty-Seventh Yearbook of the National Society for the Study of Education* is devoted to the influence of nature and nurture upon achievement.

[2] Thorndike, E. L., and others.—*The Measurement of Intelligence.* New York: Bureau of Publications, Teachers College, Columbia University, 1925, p. 416.

[3] Spearman proposed this theory as early as 1904 (Spearman, C.—"'General Intelligence,' Objectively Determined and Measured," *American Journal of Psychology*, 15:201–93, April, 1904). His latest exposition of it and the mathematical argument supporting it are given in Spearman, C.—*The Abilities of Man: Their Nature and Measurement.* New York: The Macmillan Company, 1927. 415 pp.

**The growth of intelligence.**—Due to the combined influence of natural maturing and training, a child's intelligence increases as he grows older; but the relation of intelligence to age is not fully understood. Thorndike[3] reports that the relation of altitude of intelligence as measured by such instruments as the National Intelligence Tests to chronological age approaches that of a parabolic curve. The annual increments in intelligence are approximately equal during the first years of the child's life but soon begin to diminish. Thorndike states, however, that in the data he has examined there is no justification for "the doctrine that the gain in altitude of intellect of the sort measured by existing intelligence tests is zero after 14, or after 15, or even after 16. It decreases, but it should not become inappreciable until 18 or later."

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[1] Thorndike, E. L.—*Educational Psychology*, Vol. III. New York: Teachers College, Columbia University, 1914, pp. 363f.

[2] The reader who is interested in these theories is referred to the references cited and to Kelley, T. L.—*Crossroads in the Mind of Man*. Stanford University, California: Stanford University Press, 1928. 238 pp.

[3] Thorndike, E. L., and others.—*The Measurement of Intelligence*. New York: Bureau of Publications, Teachers College, Columbia University, 1925, p. 466.

In this connection Thorndike[1] points out that our present intelligence tests measure the altitude of only certain segments of intellect, and that if we extended them to include such fields as "business, child management, household management, and social arrangement" we might find growth in altitude continued several years beyond eighteen or twenty.

Relatively little is known concerning the growth of the area of intellect, but Thorndike[2] apparently believes that the annual increments do not decrease as in the case of altitude of intellect.

**Intelligence a basis of predicting school achievement.**—The term "capacity to learn" suggests that a child's intelligence may be used as a basis for predicting his success as a learner. A child possessing a high degree of intelligence is expected to be highly successful as a learner; one possessing a low degree of intelligence is expected to be relatively unsuccessful. Since other factors affect a child's success as a learner, it is obvious that the relationship between intelligence and school achievement varies among pupils and probably for the same pupil at different times.[1] Furthermore, a prediction of a child's future success implies that his I.Q. is accurately measured and will remain constant. Consequently, predictions based on intelligence will be subject to error, but it is generally agreed that usually they are sufficiently accurate to be very useful in dealing with children in school. The degree of accuracy to be expected in predictions can be better understood after the measurement of intelligence has been considered.

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[1] Thorndike, E. L., and others.—*The Measurement of Intelligence.* New York: Bureau of Publications, Teachers College, Columbia University, 1925, p. 468.

[2] *Ibid.*, p. 467.

**The general plan of measurement.**—The general plan of measuring intelligence is to request the child to give an observable performance which experience has shown to be useful as an index of intelligence. For example, the performance given in response to a list of arithmetical problems has been found to be a useful index of the intelligence of school children above the primary grades. An arithmetical-reasoning test forms a part of many of the instruments for measuring intelligence. This plan of measurement is sometimes described by saying that we measure a child's intelligence or capacity to learn by measuring his performance on certain types of achievement tests. Strictly speaking, we do not measure intelligence. We measure certain achievements, and from the results obtained we infer the status of the child's intelligence.

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[1] "Nature and Nurture: Their Influence Upon Achievement" is the title of Part II of the *Twenty-Seventh Yearbook of the National Society for the Study of Education.* (Published by the Public School Publishing Company, Bloomington, Illinois.) This volume includes an annotated bibliography of 239 references. In his comments Terman states that although the investigations reported in the Yearbook are "far from conclusive, the evidence suggests that subject mastery is less easily influenced by ordinary differences in school attendance, by ordinary differences in school expenditures, and by ordinary differences in teacher merit than most of us have assumed; also that it is more influenced by mental level than many have assumed."

TERMAN, L. M.—"Reply to Criticisms of Part I and Introducing Part II of the 1928 Yearbook of the National Society for the Study of Education," *Journal of Educational Psychology*, 19:372, September, 1928.

**Binet's pioneer work.**[1]—The beginnings of our present tests for measuring intelligence are found in the work of a French psychologist, Alfred Binet, who faced the problem of selecting the children who probably would not succeed in the regular schools. In collaboration with T. Simon he published his first scale in 1905. This scale consisted of thirty tasks or exercises,[2] which were arranged in order of increasing difficulty, but they were not grouped according to mental age. In 1908 a revision of the scale was published in which the tests were standardized by ascertaining the per cent of children of the different ages who were able to do each of them successfully. If from 60 to 90 per cent of typical children of a given age were able to do a test correctly it was considered "standard" for that age.[3] In the revised form of the scale, the "standard tests" for each age were grouped together.

**The Stanford Revision of the Binet-Simon Tests.**—Revisions of the Binet-Simon Tests have been made by several American psychologists. The revision by Goddard[4] in 1911 was the first made in America. Another important revision has been made by Kuhlmann.[1] The Stanford Revision by Terman in 1916 is the best known and is to-day the standard instrument for individual testing. It is made up of a set of six regular exercises and one or more alternates, for each year from three to ten inclusive. For year twelve there are eight exercises, and for years fourteen, sixteen, and eighteen, there are six regular exercises with alternates for each year.[2] The exercises for the third and ninth years are described to illustrate the scale.

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[1] For an account of work in this field that preceded that of Binet see FREEMAN, F. N.—*Mental Tests.* Boston: Houghton Mifflin Company, 1926, Chapter II. PINTNER, RUDOLF.—*Intelligence Testing.* New York: Henry Holt and Company, 1923, Chapter I.

[2] Some of the original exercises are included in the Stanford Revision. See pages 266–67.

[3] For a more complete description of Binet's scales see PINTNER, RUDOLF.—*Intelligence Testing.* New York: Henry Holt and Company, 1923, pp. 93–102.

[4] GODDARD, H. H.—"Two Thousand Normal Children Measured by the Binet Measuring Scale of Intelligence," *The Pedagogical Seminary,* 18:232–59, June, 1921.

GODDARD, H. H.—"A Revision of the Binet Scale," *Training School Bulletin,* 8:56–62, 1911.

### Year III

1. Examiner says: "Show me your nose, eyes, mouth, hair." Passed if 3 out of 4 are correct.
2. "What is this?" Examiner shows in turn a key, a penny, a closed knife, a watch, a pencil. Passed if 3 out of 5 are correct.
3. "Tell me everything you see in the picture." The three pictures used are, The Dutch Home, The Canoe, and The Post Office Scene.
4. If S[3] is a boy, E asks, "Are you a little boy or a little girl?" If S is a girl, E asks, "Are you a little girl or a little boy?"
5. "What is your last name?"
6. "Say just what I say:
   a. I have a little dog.
   b. The dog runs after the cat.
   c. In summer the sun is hot.

   Passed if 1 of 3 is correct.

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[1] Kuhlmann, F.—"A Revision of the Binet-Simon System for Measuring the Intelligence of Children." Monograph Supplement of *Journal of Psycho-Asthenics*, September, 1912. 41 pp.

Kuhlmann, F.—"Some Results of Examining a Thousand Public School Children, with a Revision of the Binet-Simon Tests of Intelligence by Untrained Examiners," *Journal of Psycho-Asthenics*, 28:150–79, 233–69, March, June, 1914.

Kuhlmann, F.—*A Handbook of Mental Tests.* Baltimore: Warwick and York, Inc., 1922. 208 pp.

[2] There are no tests for years eleven, thirteen, fifteen, and seventeen.

[3] S = Subject. E = Examiner.

### Year IX

1. S must name (a) day of week, (b) month, (c) day of month, and (d) year. Passed if a, b, and d are correct and error in c is not more than 3 days.
2. E presents five weighted cubes which all look alike. They weigh 3, 6, 9, 12, and 15 grams. S must arrange them in order of weight twice out of three trials.
3. S makes change without use of coins, paper, or pencil. S must take 4c from 10c; 12c from 15c, and 4c from 25c. Passed if 2 of 3 are correct.
4. S must repeat 4 digits backwards. E reads one per second.
   6–5–2–8........4–9–3–7........8–6–2–9
   Passed if 1 of 3 is correct.
5. S must make one sentence of not over two coördinate clauses which include the three words: (a) boy, river, ball; or (b) work, money, men; or (c) desert, rivers, lakes. Passed if 2 of 3 are correct.
6. S must give three rhymes for each word. One minute is allowed for each word. The words are: day, mill, and spring. Passed if three rhymes are furnished for each of two of the words.

**Method of administering the Stanford Revision.**—The examiner tests one child at a time and the exercises are presented to the child by means of spoken directions. The test should be given in a quiet room where there is freedom from distraction, and a friendly attitude between examiner and subject should be maintained. The examiner is directed to make sure that the subject understands what is to be done, and in all cases the burden of proof is with the examiner to show that the subject has responded in a way that is representative of his ability. When the examiner has arranged the necessary materials,[1] he proceeds by giving the set of exercises for the highest year in which he judges the subject will pass all of them. If the child does these correctly, he passes to those for the higher years until the exercises become so difficult that the child is unable to do them. If the child fails to do all of the exercises of the first set, the examiner tries those for lower years until a set is found which is sufficiently easy for the child.

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[1] The Stanford Revision of the Binet-Simon Tests is published by Houghton Mifflin Company.

**Scores secured.**—The score yielded directly by the Stanford Revision of the Binet-Simon Tests is called "mental age" (M.A.). It is found by adding to the highest year in which all of the exercises are passed the credits made on the groups of exercises for the following years. For example, if a child does correctly all of the exercises in Year VIII, three in Year IX, two in Year X, and one in Year XII, his score would be recorded as follows:

| | | |
|---|---|---|
| VIII. | 8 years | 0 months |
| IX. | —— | 6 months |
| X. | —— | 4 months |
| XI. | —— | 2 months |
| Mental Age. | 9 years. | |

A measure of relative intelligence or degree of brightness is obtained by the formula

$$\frac{\text{mental age}}{\text{chronological age}} \times 100 = \text{I.Q.}$$

This measure is called "intelligence quotient" or more briefly I.Q.

The mental age score is interpreted to be the measure of the child's general mental ability. Within the limits of the test's capacity to measure intelligence, all children of the same mental age are assumed to have equal ability to do ordinary school work, handle abstract relations, and the like, regardless of their chronological ages. The intelligence quotient (usually written I.Q.) is interpreted to mean the ratio of the child's mental age to the mental age of a typical or normal child of the same chronological age. If a child's I.Q. is 100, this means that he possesses the degree of intelligence corresponding to the average mental age of all of the children of his chronological age. An I.Q. greater than 100 means that the child is bright, that is, he possesses a higher degree of intelligence than the average child of his age. Similarly an I.Q. less than 100 means the child possesses a lower degree of intelligence than the average child of his age.[1]

**A typical group-intelligence examination.**[2]—An approach to the description of the measurement of intelligence by means of group examinations[3] may be made by describing the Illinois General Intelligence Scale which consists of seven tests:

1. Analogies
2. Arithmetic problems
3. Sentence vocabulary
4. Substitution
5. Verbal ingenuity
6. Arithmetical ingenuity
7. Synonym-antonym

Each of these tests is preceded by fore-exercises designed to acquaint the pupils with the nature of the test exercises to which they are asked to respond. As they do the fore-exercises of a test, the pupils are told the correct answer, and are given an opportunity to ask questions if they do not understand the nature of the exercises. The character of the seven tests is illustrated by the fore-exercises.

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[1] The meaning of the I.Q. is treated more fully on pages 275f.

[2] For a list of group-intelligence examinations, see Freeman, F. N.—*Mental Tests.* Boston: Houghton Mifflin Company, 1926, pp. 181–90.

[3] The term "examination" is used because most instruments for measuring intelligence consist of a battery or group of tests. This is true even though the word "test" frequently appears in the title as in the case of the National Intelligence Tests.

### No. 1—Analogies

Look at this line: (a) sky, blue, grass—**table, green, warm, big.**

Notice the four words in heavy type. One of them—**green**—has a line drawn under it. Grass is green just as the sky is blue.

Look at line (b) below: A fish swims and a man does what? Draw a line under the one word of the four in heavy type which tells what a man does.

Now look at line (c): Night means the opposite of day. What word means the opposite of white? Draw a line under it.

(b) fish—swims:: man—**paper time walks girl**
(c) day—night:: white—**red black clear pure**

### No. 2—Arithmetic Problems

On the next sheet there are a number of arithmetic problems. Get the answers to them as quickly as you can. Write each answer after the word "answer," as in the problem below.

Mary had 5 apples and gave two to her brother.
How many had she left?...........Answer (3)

### No. 3—Sentence Vocabulary

Look at this exercise:

**Apples** grow on **vines roots grass trees.**

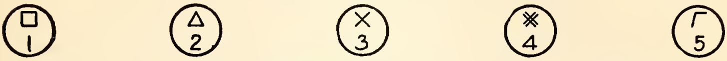
The right word is **trees** because it makes the truest sentence.

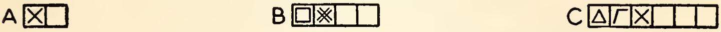
In each of the exercises below you have four choices for the last word. Only one of them is correct. In each sentence draw a line under the one of these four words which makes the truest sentence.

**People** can see through **wood stone glass iron.**
The **ear** is a part of the **legs arms head feet.**
**Deserts** are crossed by **horses mules camels elephants.**

### No. 4—Substitution

Look at the sign and figure in each of the following circles:





Under the circles are some exercises having the same signs. Look at the exercise A. Find the circle in which this sign is printed. The figure 3 is in the same circle. This means that the sign in exercise A stands for 3. Write the figure 3 in the square next to the sign to which it corresponds.—Look at exercise B. There are two signs in this exercise. Find the figure which is in the same circle with the first sign. Write this figure in the first blank square.—Do the same for the second sign.—Look at exercise C. Write the figures for these signs in the three blank squares. Write them in the order in which the signs come.

### No. 5—Verbal Ingenuity

Look at line (a) below. The words of this line are "see a I man on." In this order the words do not make sense, but they can be made into a sentence if you leave out one word. The sentence is "I see a man." The word to be left out is *on*. Draw a line through it. In each of the other lines when one word is crossed out, the remaining words can be made into a true sentence. Cross out the extra word in each line.

(a) see a I man on.
(b) knife chair the sharp is.
(c) John broken window trees has the.

### No. 6—Arithmetical Ingenuity

Look at line (a) below. The numbers 2, 4, 6, 8, 9, 10, 12 count up by two's except the number 9. It is the number which does not fit in this group. Cross it out. In each of the other lines there is one number that does not fit. Find this number and cross it out.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| (a) | 2 | 4 | 6 | 8 | 9 | 10 | 12 |
| (b) | 7 | 6 | 5 | 1 | 4 | 3 | 2 |
| (c) | 1 | 2 | 4 | 8 | 16 | 17 | |
| (d) | 1 | 3 | 5 | 7 | 2 | 9 | 11 |

### No. 7—Synonym-Antonym

Look at these exercises:

(a) good—bad.........same opposite
(b) little—small.........same opposite
(c) rich—poor..........same opposite

In exercise (a) *good* means the opposite of *bad.* This is shown by a line drawn under the word *opposite.* In exercise (b) *little* means the same as *small.* Would you draw a line under *same* or *opposite ?* You would draw it under *same.* In exercise (c) do *rich* and *poor* mean the same or opposite? Draw a line under *same* or *opposite* to show your answer.

The fore-exercises are so placed in the test booklet that the pupils do not have an opportunity to see a test until they turn the page. After the fore-exercise is completed, the directions for doing the test are read, and the examiner then gives the signal to turn the page and begin work. There is a time limit for each test such that few if any pupils will complete the test before time is called. Except in Test 4 and Test 7 a pupil's score is the number of exercises done correctly. In Test 4 the score is the number of correct substitutions divided by 4, and in Test 7 it is the number of exercises done correctly minus the number done incorrectly. The score on the examination is the sum of the scores on the several tests. It is commonly called a "point score."

**Translating point scores into mental ages.**—With the exception of instruments of the Binet type, an intelligence examination yields a score in terms of points. In other words, it is expressed from an arbitrary zero point and in terms of an arbitrary and undefined unit.[1] A point score has little meaning and for many purposes it is desirable to translate it into the corresponding mental age. A basis for this translation is secured by administering the test to a large number of unselected children within the chronological age limits for which the test is designed. The scores obtained are classified on the basis of the chronological ages of the children, and the average or median score is calculated for each age. For example, in standardizing the Illinois General Intelligence Scale[2] the data shown in Table I were obtained from administering the test to the pupils in grades III to VIII in one city.

The median score for the age group 12.0 years to 12.4 years (average chronological age 12.25 years) is 63.4. Consequently a score of 63 would be translated into a mental age of 12.25 years, or 12 years, 3 months.

In Table I the numbers of pupils in both the lower and the higher age groups are relatively small, and from our knowledge of the organization of our schools we know that the pupils in these groups were selected, that is, not typical. Consequently the median point scores for ages below 9 and above 14 are not valid bases for translating scores into mental ages. This limitation may be overcome by securing groups of typical children for the lower and higher ages. This, however, is not easy to do and usually the median scores for these age groups are estimated on the basis of what is known about the growth of general intelligence.

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[1] It would be more accurate to say "units" because it is not likely that the divisions of the scale represented by the various scores 26, 27, 28, etc., are equal. See page 289 for an elaboration of this point.

[2] Monroe, Walter S.—"The Illinois Examination," *University of Illinois Bulletin,* Vol. 19, No. 9, Bureau of Educational Research Bulletin No. 6. Urbana: University of Illinois, 1921, pp. 19f.

TABLE I.—MEDIAN POINT SCORES OF CHRONOLOGICAL AGE GROUPS.

| CHRONOLOGICAL AGE INTERVAL | AVERAGE CHRONOLOGICAL AGE | NUMBER OF PUPILS | MEDIAN POINT SCORE |
|---|---|---|---|
| 17.5—17.9 | 17.75 | 1 | 40.0 |
| 17.0—17.4 | 17.25 | | |
| 16.5—16.9 | 16.75 | 2 | 54.5 |
| 16.0—16.4 | 16.25 | 9 | 70.0 |
| 15.5—15.9 | 15.75 | 26 | 64.5 |
| 15.0—15.4 | 15.25 | 61 | 64.4 |
| 14.5—14.9 | 14.75 | 124 | 71.4 |
| 14.0—14.4 | 14.25 | 191 | 68.9 |
| 13.5—13.9 | 13.75 | 244 | 73.5 |
| 13.0—13.4 | 13.25 | 297 | 70.2 |
| 12.5—12.9 | 12.75 | 306 | 67.2 |
| 12.0—12.4 | 12.25 | 304 | 63.4 |
| 11.5—11.9 | 11.75 | 308 | 52.8 |
| 11.0—11.4 | 11.25 | 298 | 54.8 |
| 10.5—10.9 | 10.75 | 316 | 43.8 |
| 10.0—10.4 | 10.25 | 290 | 40.9 |
| 9.5— 9.9 | 9.75 | 297 | 35.9 |
| 9.0— 9.4 | 9.25 | 285 | 30.1 |
| 8.5— 8.9 | 8.75 | 216 | 26.2 |
| 8.0— 8.4 | 8.25 | 163 | 20.0 |
| 7.5— 7.9 | 7.75 | 33 | 27.5 |
| 7.0— 7.4 | 7.25 | 14 | 23.0 |
| 6.5— 6.9 | 6.75 | 2 | 20.0 |

If the median scores in Table I and the corresponding ages are represented graphically, the points for ages 9 to 14 tend to form a straight line. Similar data for other intelligence tests also indicate that up to about fourteen years the graph representing the relationship between intelligence-test scores and chronological age approaches a straight line.[1] At this age, the rate of growth begins to decrease, and, until recently, psychologists believed that, in general, mental growth ceased about the sixteenth year or even earlier. Recent inquiries indicate that mental growth continues beyond the sixteenth year, probably until nearly the twenty-fifth year. If a test-maker secures median scores for a number of typical age groups, then he can draw reasonably accurate extensions.

**Measures of relative intelligence.**[2]—For some purposes we desire to know a child's relative intelligence or the degree of his brightness. One such index is secured by dividing his mental age by his chronological age.[3] This quotient, called the I.Q., has the property of being approximately constant from year to year for the period during which there is a rectilinear relation between mental age and chronological age. By the I.Q., a child's mental age can be predicted at any future date within this period. For example, if at age 8 a child has a mental age of 10 his I.Q. is 125 and at the age of 12 his mental age will be 15. But the slowing down of mental growth after the fourteenth year changes the meaning of the I.Q.

The changed meaning of the I.Q. may be illustrated as follows. A child having a mental age of 14.4 years at the age of 12 has an I.Q. of 120. At the age of 20 his mental age will be considerably less than 24 years (20 × 1.20) and at the age of 30 his mental age might be less than 30 years. But from one point of view this statement is meaningless, because mental age has no standard meaning for chronological ages beyond sixteen or, at most, eighteen. From another point of view this statement is incorrect, for the child would develop into a superior adult and as such his intelligence would be above the average for his age. The decreasing rate of mental growth in combination with certain other conditions creates a situation such that the quotient obtained by dividing mental age by chronological age cannot be used for ages beyond fourteen, or, at most, beyond sixteen.

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[1] Freeman, F. N.—*Mental Tests.* Boston: Houghton Mifflin Company, 1926, pp. 329–43. Thorndike describes this graph as a section of a parabolic curve. See pages 262–63.

[2] For a more extended treatment, see *ibid.*, pp. 275–85.

[3] See page 268.

The I.Q. was originated in connection with the Binet Scale and it has been shown that it is not a suitable measure for use with the ordinary group intelligence test.[1] When it is used with such tests its meaning is modified and this fact should be remembered by those who calculate I.Q.'s from the scores yielded by group intelligence tests. Modification of the meaning of the I.Q. is slight in some cases, but one should be cautious in using it with group intelligence tests.

Several substitutes for the I.Q. have been proposed. Miller[2] has suggested an index to be obtained by translating the I.Q.'s "into tenths of S.D.[3] of the distribution, taking negative 5 S.D. as zero." This method, however, merely serves to make the index obtained from the use of different tests equivalent, but it does not make the indices for different ages equivalent in meaning. Otis has proposed another type of index of the relation between mental age and chronological age, which he calls the "index of brightness," or the I.B. In the case of the Otis Group Intelligence Scale it is calculated by subtracting the norm for the child's age from his score on the test and then adding this difference to 100.[1] Another proposal is to translate the point scores into percentile scores.[2] The percentile method, however, has certain limitations. The units are not equal. The difference between 55 and 60 is not equal to the difference between 90 and 95. For some purposes this limitation is not significant, but one using the method should keep this limitation in mind.

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[1] Freeman, *op. cit.*, p. 281.

[2] Miller, W. S.—"The Variation and Significance of Intelligence Quotients Obtained from Group Tests," *Journal of Educational Psychology*, 15:359–66, September, 1924.

[3] S. D. is an abbreviation for "standard deviation." The Greek letter σ is also used for this purpose.

**Non-verbal intelligence examinations.**—Group intelligence examinations of the type described in the preceding pages require that the person being tested be able to read. In order to measure the intelligence of illiterates or persons not able to read the English language, several tests have been devised which do not involve reading. The Army Group Intelligence Examination, Beta, was the first test of this type.[3] Other non-verbal tests are: Dearborn Group Test of Intelligence, Series I, Revised Edition (Grades I to III); Dearborn Group Test of Intelligence, Series II, Revised Edition (Grades IV to IX); Haggerty Intelligence Examination, Delta 1 (Grades I to III); Myers Mental Measure (Grades I to XII); Pintner Non-

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[1] The difference is to be subtracted if it is negative, and added if positive.

[2] WOOLLEY, H. T.—"A New Scale of Mental and Physical Measurements for Adolescents and Some of Its Uses," *Journal of Educational Psychology*, 6:521–50, November, 1915. This appears to be the first reported use of the percentile scale.

[3] See FREEMAN, *op. cit.*, pp. 153f. for a description of this test.

Verbal Mental Tests (Grades II to VIII); Pressey Primary Classification Tests[1] (Grades I and II); and Detroit First-Grade Intelligence Test.

**Assumptions upon which the measurement of intelligence is based.**—As pointed out on page 265, the measurement of intelligence is made "indirectly" by measuring certain achievements of the child. In other words, we measure a child's capacity to learn by measuring what he has learned. This procedure and the method of interpreting the resulting scores imply certain assumptions of which the following are most important.

1. *It is assumed that all children of a given chronological age to whom the test may be given have had equal opportunities to acquire the achievements measured.* This assumption is apparent in the method of interpreting test scores. A common norm is used for all children; that is, a given score, e.g., 45, is translated into the corresponding mental age without any reference to the particular training the child has had. In other words, the scores of all children are treated alike in interpreting them—hence the implicit assumption that all *children of a given chronological age* have had equal opportunities to learn the things the test calls for.[2]

Equal opportunity to learn is secured when the exercise is foreign to the experience of all children. This probably would be approximately true of the digit-symbol test described on page 271. Pupils are trained to do arithmetical examples and problems, and the opportunities to learn to do these exercises are approximately equal for pupils belonging to the same grade. Examination of the other types of exercises described on pages 270f. will show that under typical American conditions the opportunities to learn to do them are approximately equal for most children of a given age.[1] There are, however, exceptions in the case of some pupils. The opportunities of the child reared in a large city may be somewhat different from those enjoyed by the child in the small city or rural district. The child in a poor home does not have the same opportunities as the child in the better class of homes. The foreign-born child or one living in a home where the English language is not spoken does not have the same opportunities as the child in the typical American home. The significance of such variations in educational opportunities depends upon the test exercises that are used. Test-makers endeavor to select exercises which all children will have had approximately equal opportunities to learn. They have succeeded to a large degree, but caution should be exercised in interpreting the scores yielded by a group test when the educational opportunities of the children have not been typical. This admonition is especially pertinent in the case of individual children whose educational opportunities are different from the average.

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[1] This is a revision of the original Pressey Primary Scale which has been very widely used.

[2] The phrase "of a given chronological age" is necessary to make the statement strictly accurate. For example, it is not assumed that a fourth-grade pupil has had the same opportunity to learn as an eighth-grade pupil.

2. *It is assumed that we can secure a typical functioning of a given ability for the purpose of measurement.* This assumption is implied in our use of all standardized objective tests. When a test is given to a group of pupils we assume that we have secured a typical functioning[2] of the ability that it measures in the case of each pupil. We,

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[1] The effects of practice are considered on pages 284-85.

[2] The meaning of this phrase is "functioning that is typical for each child."

furthermore, assume that each pupil has had a reasonable opportunity to demonstrate his ability, unless it is obvious that he has not. In other words, our customary administration of standardized objective tests implies that we can secure a typical functioning of a given ability whenever we ask for it. It is only necessary to present the test to the pupils and we shall secure the functioning of the ability we desire to measure.

The discussions of reaction tendencies[1] and of the factors that affect learning activity[2] suggest that this assumption may not be fully realized. Some pupils may be stimulated to unusual effort; others may be indifferent. Some may have an interfering mind-set; others may have a mind-set that facilitates responding to the test. Hence there is a second reason for exercising caution in interpreting and using intelligence-test scores, especially those yielded by group examinations.

3. *It is assumed that the testing conditions can be controlled, not only through a single testing period, but also on subsequent occasions and by different examiners.* Testing conditions include the explanation of the test, the timing of it, the attitude of the pupils, the effort which they make, the lighting of the room, and even the temperature and atmospheric pressure. In fact, testing conditions include all factors that may affect the performances of pupils. It is obvious that if these factors are not controlled so that their effect upon the performance is the same for all pupils, even when they are tested at different times and by different persons, the use of the same norms[3] for interpreting all scores will lead to erroneous interpretations. It is

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[1] See pages 100f.

[2] See pages 220f.

[3] Norms are used for translating scores into mental ages.

important that an examiner follow carefully the directions for administering the test, and if he fails to control the testing conditions, he should be cautious in comparing the scores with the norms.

**Limitations of our present intelligence tests: accuracy and validity.**—When two or more of our present intelligence examinations are administered to the same group of children under as nearly the same conditions[1] as possible the two sets of scores will not be in complete agreement. If they are compared by calculating the coefficient of correlation the resulting index of agreement will be materially less than 1.00.[2] Hence it is obvious that if we accept one of the intelligence examinations as yielding valid and accurate measures, the other does not. Since it is extremely unlikely that any one of our present intelligence examinations is a "perfect" instrument, it follows that all fail to yield valid and accurate measures.

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[1] The conditions cannot be the same. One test must be given first and this act produces a change in the conditions. Other causes are likely to produce additional changes.

[2] The coefficient of correlation is a statistical device for indicating the degree of agreement between two sets of paired facts such as chronological ages and weights, grades in Algebra and in English, and the like. The facts are paired off by reason of the fact that there is one from each group for each child. Two sets of facts are said to be in complete agreement when the largest in one group is paired with the largest in the other, the second largest with the second largest, and so on. This degree of agreement is represented by a coefficient of correlation of 1.00. Complete inverse correlation in which the largest of one group is paired with the smallest in the other, the second largest with the second smallest, and so on is represented by a coefficient of —1.00. No agreement between the two sets of paired facts is represented by a coefficient of 0.00.

The interpretation of a coefficient of correlation, commonly designated as $r$, is difficult and there is not space here for an adequate treatment. Probably the most important thing for the reader to remember is that $r$ must be greater than .90 in order to be interpreted as meaning approximately complete agreement. An $r$ of .50 does not mean 50 per cent agreement or halfway between no agreement ($r = 0.00$) and complete agreement ($r = 1.00$). In order to attain the halfway stage, $r$ must be approximately .87.

The limitations of our present intelligence examinations, however, cannot be dismissed with the statement that they fail to yield valid and accurate measures. A more analytic discussion is required. The two fundamental questions to be considered are: (1) What trait or combination of traits does a given intelligence test measure? (2) How accurately does it measure this trait or combination of traits? It is, however, more convenient to consider: (1) How accurately does a given test measure what it measures? (2) How nearly do the measures it yields agree with true measures of intelligence? The first of these questions is considered under the head of *accuracy* and the second under the head of *validity*.

**The accuracy of test scores.**[1]—In the field of physical measurement, accuracy refers to the magnitude of the differences between the obtained measures and the true measures. For example, if in measuring the length of a bar the obtained measure is 47.6 mm. and the true length 48.3 mm., the error is −.7 mm. Usually when we speak of the accuracy of a measurement of a physical object, we refer to the magnitude of the error, and as a rule the error can be determined with a high degree of precision for any particular measurement. When applied to test scores, accuracy usually has a modified meaning and refers to the "average" error in a group of scores. As a rule it is not practicable to ascertain the error in any particular score, and hence it is necessary to be content with a description of the general condition.

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[1] For a discussion of errors in terms of causes see HOLZINGER, K. J.—"An Analysis of the Errors in Mental Measurement," *Journal of Educational Psychology*, 14:278–88, May, 1923. Scoring as a source of error has been investigated by PINTNER, RUDOLF.—"Accuracy in Scoring Group Intelligence Tests," *Journal of Educational Psychology*, 17:470–75, October, 1926.

Test scores are subject to two kinds of errors—constant and variable.[1] A constant error is in the same direction for all of the scores in the group being considered.[2] In a particular case it may be positive—that is, all of the scores may be larger than they otherwise would have been; or it may be negative—that is, all of the scores may be smaller than they otherwise would have been. The effect of practice is an illustration of a positive constant error. If the time for a test is shortened, a negative constant error will probably be introduced.

A variable error, as the name implies, varies within the group of scores considered. In a large group, half of the variable errors will be positive and half will be negative. A few will be relatively large, but most of them will be small. If the variable errors are represented graphically, the curve will be bell-shaped with the center at zero.[3] Variable errors in test scores are due to several causes. One pupil may be confused by the test and not do himself justice. Another tries very hard and makes a higher score than he normally would make. One pupil may find the exercises easy because of his training. Another pupil may find them difficult because his training has been different.[4]

Although it is desirable to consider these two types of errors separately, the reader should remember that they occur together, and hence the actual error in the score of a given pupil is the algebraic sum of the constant error and the variable error.

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[1] The terms "systematic" and "chance" are sometimes used to designate these types of errors.

[2] This group may be those of a class, a school, several schools, or any other group.

[3] See Figure 27, page 345.

[4] For a discussion of the causes of variable errors see SYMONDS, P. M.—"A Study of Extreme Cases of Unreliability,' *Journal of Educational Psychology*, 15:99–106, February, 1924.

**The magnitude of constant errors in test scores.**—As a rule it is not possible to know the exact magnitude of the constant error in a group of test scores. Frequently the user of a test may be able to secure evidence that will give some indication of the magnitude, especially as to whether the constant error is positive or negative. It has been demonstrated that practice on a test, even that due to taking the test on a previous occasion, tends to introduce a positive constant error. Glick[1] gave a series of intelligence tests (so constructed as to be similar to Army Alpha) to certain groups of pupils. One form of Army Alpha was given on the first day and another form on the twentieth day. With the exception of one group, which had a large initial score, the gains in average scores were in excess of 75 per cent of the average initial score. Odell[2] followed up a number of the pupils Glick tested and gave a form of Army Alpha to them about two years later. From the data obtained in this way and from some other data, Odell concluded that "such previous testing and even occasional special training as falls within the experience of most public-school pupils is not likely to cause serious errors to enter into the scores which they make upon intelligence tests at some later date, and that, therefore, there is ordinarily no necessity to attempt to correct these scores for any practice effect. This conclusion, however, does not hold in case a test is given within a short time after a previous test has been taken."

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[1] Glick, H. N.—"Effect of Practice on Intelligence Tests," *University of Illinois Bulletin,* Vol. 23, No. 3. Bureau of Educational Research Bulletin No. 27. Urbana: University of Illinois, 1925. 23 pp.

[2] Odell, C. W.—"Some Data as to the Effect of Previous Testing upon Intelligence Test Scores," *Journal of Educational Psychology,* 16:482–86, October, 1925.

Regular class work may function as coaching for an intelligence test. In an investigation conducted by the Bureau of Educational Research of the University of Illinois, it was found that for one group of pupils the intelligence-test scores showed an increase of more than 4.5 years in mental age during a period of six months.[1] Such an increase in actual mental age is impossible, and inquiry revealed that the teachers of these pupils had been using exercises of the type employed in parts of the intelligence test as learning exercises in the language work. There was no possibility of explicit coaching for the second test because the one used was not constructed until shortly before it was given. Hence it appears that in this case regular class work functioned as coaching for an intelligence test and produced a constant error equivalent to approximately four years of mental age. This case is undoubtedly exceptional, but it demonstrates what may happen, and it is likely that small positive constant errors are frequently introduced in this way.

In view of the impossibility of determining the exact magnitude of constant errors, it is important to note that when test scores are used only for ranking pupils or for dividing the group into sections, constant errors may be neglected.

**Variable errors in intelligence-test scores.**—An index of the variable errors in the scores that a given test yields may be obtained by readministering the test to the same group, preferably using a duplicate form, and calculating the coefficient of correlation between the two sets of scores.[1] This is called the *coefficient of reliability*. The reliability coefficients of intelligence tests vary, the best tests having coefficients above .90 and a few above .95.

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[1] MONROE, WALTER S.—"The Constant and Variable Errors of Educational Measurements," *University of Illinois Bulletin*, Vol. 21, No. 10, Bureau of Educational Research Bulletin No. 15. Urbana: University of Illinois, 1923. 30 pp.

As pointed out on page 281, the interpretation of a coefficient of correlation is difficult.[2] Probably the most helpful plan is to use the corresponding probable error of estimate, or probable error of measurement.[3] Herring[4] has prepared a table showing the number of pupils per thousand whose scores involve "errors of estimate equalling or exceeding two months, four months, etc.," for various values of $r$. According to this table when $r = .95$, 787 out of 1000 are "mismeasured" by two months or more; 589, four months; 418, six months; 107, twelve months.

The facts just presented make it clear that intelligence-test scores involve variable errors. Although these errors may be described for a group of scores, it is not possible to determine under ordinary conditions the magnitude of the variable error in the score of an individual pupil. It should be noted, however, that the effect of variable errors upon an average or median score of a group becomes relatively small when the group is large. In comparing very large groups, variable errors may become negligible.

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[1] The presence of a constant error in one or both of the sets of scores does not affect the coefficient of correlation.

[2] For a discussion of the interpretation of the coefficient of correlation, see ODELL, C. W.—"The Interpretation of the Probable Error and the Coefficient of Correlation," *University of Illinois Bulletin*, Vol. 23, No. 52, Bureau of Educational Research Bulletin, No. 32. Urbana: University of Illinois, 1926, pp. 33f.

[3] If we take two sets of paired scores which are not in perfect agreement, and make changes in one set of scores so that perfect correlation is secured, and if the changes are made in such a way that the sum of their squares is a minimum, the amount of change in a given score is the "error of estimate," and the *probable error of estimate* is the median of the several errors of estimate. The probable error of estimate becomes the probable error of measurement when one set of scores are true scores, i. e., do not involve any variable errors.

[4] HERRING, J. P.—"The Verification of Group Examinations," *Journal of Educational Psychology*, 15:596–602, December, 1924. For another critical study of several group intelligence tests see SLOCOMBE, C. S.—"The Measurement of Intelligence," *Journal of Educational Psychology*, 17: 600–07, December, 1926.

**Validity of intelligence-test scores.**—In considering how nearly the scores yielded by a given test agree with true measures of intelligence, we are dealing with the accuracy of the scores as well as with the question of what the test measures. If a test were constructed so that the scores yielded involved no errors, either constant or variable, it would not necessarily be valid. It would, of course, measure something with perfect accuracy, but that something would not necessarily be "capacity to engage in the learning activities of the school in such a way that the process of learning is efficient."[1] The failure to measure intelligence as defined would result in the scores being erroneous unless that which the test does measure is perfectly correlated with intelligence as defined.[2] The effect of lack of validity in a test is to introduce errors in the scores yielded. These are combined with the errors of measurement described in the preceding pages and in the case of a particular score it is impossible to effect a separation, but for purposes of discussion it is helpful to distinguish between "errors of validity" and "errors of measurement."

This distinction between reliability or accuracy and validity is important because it is relatively easy to determine the reliability of a test, and there is a tendency to assume that a reliable test is also a valid one.[1]

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[1] This statement would be true if some other definition of intelligence were inserted.

[2] There might be constant errors even in this case.

The determination of the validity of an intelligence test would be simple if we possessed some means of securing true measures of intelligence as defined. In the absence of any such means, test-makers have used a variety of approximations. The most widely used criterion measure is that yielded by a careful application of the Stanford Revision of the Binet Test. The scores yielded by this test are not accepted as absolutely true measures of intelligence and consequently supplementary criteria are applied.[2] A method frequently used is to administer the test to groups of persons generally recognized as differing in intelligence. For example, children secluded in institutions for the feeble-minded are recognized as being inferior in intelligence to children of corresponding chronological age enrolled in public schools. Children enrolled in the fifth grade are recognized as being on the average below the mental level of children in the sixth grade. A test that yields scores which on the average agree with the consensus of opinion about the relative mental status of such groups is accepted as satisfying one criterion of validity.

An extended consideration of validity would be out of place in this volume.[3] A number of existing tests of intelligence measure somewhat the same trait, and scores obtained by careful administration of them agree fairly closely with the judgments of "sensible people, psychologists, and teachers" in regard to the intellectual status of children and adults.[1] Hence when using one of the more carefully constructed intelligence tests a person is justified in considering the "errors of validity" to be small in comparison with the "errors of measurement." It is important to remember, however, that proving a test to be reliable does not demonstrate its validity.

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[1] This distinction between reliability and validity has not been made by many writers and the reader should bear this fact in mind in reading other discussions of the topic.

[2] Kohs applied ten criteria in determining the validity of a block-design test. Kohs, S. C.—*Intelligence Measurement.* New York: The Macmillan Company, 1923, pp. 172f.

[3] The reader who is interested may consult Freeman, F. N.—*Mental Tests.* Boston: Houghton Mifflin Company, 1926, Chapter IX.

**Other limitations of our present intelligence tests.**—Our present intelligence tests are subject to other limitations than those included under accuracy and validity. Thorndike[2] has pointed out that in addition to not knowing just what the instruments measure, we have failed to establish a true zero point and to construct a scale of equal units. It appears that a score of zero on any of our present intelligence tests does not mean zero intelligence. Consequently a score of 50 does not represent twice as much intelligence as a score of 25 or half as much as a score of 100. Even when translated into mental ages, it is likely that the zero point is not a true one. The lack of equal units makes the difference between a score of 40 and 50 unequal to the difference between a score of 90 and 100.

The lack of a true zero point and of equal units is very significant for some purposes, but these limitations are not serious for most of the uses of intelligence tests that the teacher is interested in. As a rule, the teacher will not make erroneous interpretations if he neglects these two limitations.

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[1] Thorndike, E. L., and others.—*The Measurement of Intelligence.* New York: Bureau of Publications, Teachers College, Columbia University, 1925, p. 10.

[2] *Ibid.*, Chapter I.

Another limitation applies to the calculation of the I.Q. for persons older than thirteen or fourteen years. The calculation of the I.Q. by the method described on page 268 assumes a rectilinear relation[1] between chronological age and mental age. The chronological age of a person increases with the passage of time, but we know that the rate of increase of mental age decreases after the age of thirteen or fourteen years and probably ceases to increase at all after the age of twenty or twenty-five. Consequently, the I.Q. of persons older than thirteen or fourteen years cannot be calculated by dividing the mental age by the chronological age.[2]

**Measurements of the intelligence of college students and other adults.**—Although intelligence tests designed for use in the high school or even in the elementary school have been administered to college students and other adults, the measures secured in this way are subject to certain criticisms. In the first place, many of the exercises employed in intelligence tests designed for ages ten to fifteen are not typical of the normal activities of the college student or other adults. For example, pupils studying arithmetic are accustomed to calculating and to solving verbal problems. College students do relatively little calculating and those who are studying mathematics are more accustomed to dealing with problems in college algebra, analytics, and calculus, than with the verbal problems of arithmetic. Adults not attending college do even less calculating, unless it happens to be required in their vocation, and they probably have fewer occasions to solve verbal problems. Furthermore, college students and other adults have acquired general patterns of conduct, such as a critical attitude and a tendency to be more deliberative, which tend to influence their responses to many of the exercises used in intelligence tests. Adults develop specialized interests. As a result they become familiar with the tasks in a relatively narrow field and lose much of the expertness they may have possessed in other fields. Consequently, they are handicapped in responding to intelligence tests designed for pupils from ten to fifteen years of age, and it is manifestly unfair to measure their intelligence by means of such instruments, especially if the scores are interpreted by comparison with the same norms.

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[1] A rectilinear relation is one in which the two variables increase at the same rate. For example, in purchasing a commodity such as coal at a fixed rate per unit, there is a rectilinear relation between the number of units purchased and the total amount paid. As the number of units is increased, the total amount paid increases and at the same rate.

[2] See pages 275f.

Since the construction of intelligence tests is based on the principle that the persons to whom a test may be administered will have had equal opportunities to learn to do the exercises that make up the test,[1] it is obvious that special intelligence tests should be devised for college students and for other adults, and probably for different occupational groups. Several such tests have been devised. The Army Alpha intelligence examination was designed for adult males. Thorndike has prepared an intelligence examination for high-school graduates which has been used extensively for measuring the intelligence of college entrants.[2]

**The constancy of the I.Q.**—The use of an intelligence-test score or mental age as a basis for predicting the intellectual status of a child at some future date is based on the hypothesis that the I.Q. remains constant—that is, that the ratio of a person's mental age to his chronological age remains the same as he grows older. Since test scores are subject to errors, it is obvious that the I.Q.'s calculated from measurements made at intervals would vary somewhat, but the hypothesis is that the true I.Q. of a child remains essentially constant. This hypothesis has been questioned and there have been many investigations to determine its validity.[1]

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[1] See footnote on page 278.

[2] For a description of this test see Wood, B. D.—*Measurement in Higher Education.* Yonkers: World Book Company, 1923, Chapter II to V and Appendices I to III.

The conclusion of Baldwin and Stecher[2] is generally accepted: "An analysis of the individual growth curves shows that the I.Q. is only approximately constant during successive examinations. The amount of difference between I.Q.'s obtained at various examinations is sufficiently small, and the correlations between the examinations are sufficiently high, with small probable errors of estimate, to permit of predicting from an earlier examination what the individual's later development will be." Freeman[3] expresses essentially the same conclusion.

Subnormal children and gifted children do not show as high a degree of constancy in the I.Q. as is exhibited by normal children. Kuhlmann[4] has pointed out, however, that absolute constancy is not necessary for purposes of prediction in such cases. If we know that the I.Q. is approximately constant for a certain period for normal children, and that it varies in known ways for other children and for other life periods, this is sufficient for purposes of prediction.

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[1] Obviously the problem involves that of the relative influence of nature and nurture on intelligence. See pages 255f.

[2] Baldwin, Bird T., and Stecher, L. I.—"Mental Growth Curve of Normal and Superior Children," *University of Iowa Studies in Child Welfare*, Vol. 2, No. 1. Iowa City: University of Iowa, 1922, p. 59.

[3] Freeman, F. N.—*Mental Tests.* Boston: Houghton Mifflin Company, 1926, p. 344.

[4] Kuhlmann, F.—"The Results of Repeated Mental Re-examinations of 639 Feeble-Minded Over a Period of Ten Years," *Journal of Applied Psychology*, 5: 195–224, September, 1921.

The reader should bear in mind that the demonstration of the approximate constancy of the true I.Q. does not mean that a prediction of a given child's mental age at some future date based upon an obtained I.Q. will necessarily be approximately accurate. In order to make an accurate prediction of future mental age it is necessary to have an accurate I.Q. Since intelligence-test scores are subject to errors, both constant and variable, the I.Q. obtained for a given pupil may involve an error of sufficient magnitude to make the prediction grossly inaccurate. Consequently, predictions of future mental status should be considered subject to revision, especially when there is no assurance that the obtained I.Q. is approximately correct. Even when there is reason to believe that the I.Q. is highly accurate, one should not fail to realize that the child's mental growth is subject to environmental influences to such an extent that extreme environmental conditions may retard or accelerate it to an appreciable extent.[1]

**Limitations upon the use of intelligence-test scores.**— One of the uses of intelligence-test scores is as a basis for classifying into sections the pupils taking a subject. In sectioning a group the pupils are usually arranged in order of their point scores and those at the top are taken for the first group, those next for the second group, and so on. The usual practice is to provide for three or four sections. In view of the limitations of intelligence tests it is pertinent to ask, "What per cent of the pupils will intelligence-test scores place in the correct section?"

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[1] See page 259.

Geyer[1] gave the Otis Group Intelligence Test and the Illinois General Intelligence Scale to one hundred and twenty pupils in the junior-high-school grades of the Chicago Normal School. The coefficient of correlation between the two sets of scores was .642. He, however, states:

> If these one hundred and twenty pupils had been divided on the basis of the intelligence scores of one test into four class-sections of ordinary size, 51.6 per cent of them would have been in the wrong section according to the other test, and 31.8 per cent of them would have been out of place by an amount equal at least to half the range of such a class-section.

The Thurstone and the Brown University tests were given to fifty-four freshman college students. If these students had been grouped into two classes on the basis of the scores of one test, 26 per cent of them would have been in the wrong class according to the other. For a sophomore group of sixty-four students a classification on the basis of scores of one test would have been changed in 32.8 per cent of the cases by a reclassification on the basis of the second test.

Breed and Breslich[2] gave the Chicago Group Intelligence Test, Form A, the Otis Group Intelligence Test, Advanced Examination, Form A, and the Terman Group Test of Mental Ability, Form A, to a group of seventh-grade pupils and also to a group of ninth-grade pupils. The average intercorrelation between the scores yielded by the three tests was .77. The authors show, however, that if the pupils had been classified into three sections according to scores yielded by one test, 30 per cent would have been out of place according to one of the other tests.

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[1] Geyer, Denton L.—"The Reliability of Rankings by Group Intelligence Tests," *Journal of Educational Psychology*, 13:43–49, January, 1922.

[2] Breed, F. S., and Breslich, E. R.—"Intelligence Testing and the Classification of Pupils," *School Review*, 30:51–66, 210–26, January, March, 1922.

Brooks[1] has reported a detailed inquiry into the accuracy of sectioning pupils entering the junior high school upon the basis of I.Q.'s. Nine group tests[2] and the Stanford-Binet were administered to 108 pupils. A criterion measure was formed by taking a weighted average of the ten I.Q.'s thus obtained.[3] If this group of pupils had been classified into four sections on the basis of the I.Q.'s from a single group test, 61.5 per cent would have been placed correctly as judged by this criterion, and 34.7 per cent would have been displaced by one section. If the sectioning had been based on I.Q.'s from a pair of group tests, the corresponding per cents would have been 68.9 and 30.0.[4]

Symonds[5] concluded that "in dividing a class of normal spread ($\sigma$ = 13 I.Q.[6]) into two sections by means of the National Intelligence Scale A" 20 per cent will be placed in the wrong section and 8 per cent will be "wrongly sectioned to the extent of 5 I.Q. or more."

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[1] Brooks, F. D.—"The Accuracy of Intelligence Quotients from Pairs of Group Tests in the Junior High School," *Journal of Educational Psychology*, 18:173–86, March, 1927.

[2] The tests used were Miller, Form A; Otis Self-Administering, Form A; Illinois, Form A; Terman, Form A; Haggerty, Delta 2; National, A1; Dearborn, Revised C; Dearborn, Revised D; Pintner, Non-Language.

[3] The Stanford-Binet I. Q. was given a weight of nine and each of the others a weight of one.

[4] Brooks also states that "on the average, the I. Q.'s from any two of the group tests used in this study will have a median error of 5.53 points" according to the criterion. The average error for the tests used singly is 7.07. Hence he concludes that the average of the I. Q.'s obtained from two tests is in general about 21 per cent more accurate than the I. Q. from either.

[5] Symonds, P. M.—"The Accuracy of Certain Standard Tests for School Sectioning and Marking," *Journal of Educational Psychology*, 15:423–32, October, 1924.

[6] This expression is to be read $\sigma = 13$ points on the scale of the I.Q. If the mean I.Q. is 102, approximately 68 per cent of the group would have I.Q.'s between 89 and 115.

The results of these investigations make it clear that caution should be exercised in using intelligence-test scores as a basis for classifying pupils. If a classification is made solely upon the basis of the test scores, a considerable number of pupils will be placed in the wrong section.

**The extent to which original intellectual capacity is measured by means of intelligence tests.**—Although this topic has been referred to in the preceding pages, a more explicit treatment seems desirable. It is obvious that intelligence tests, especially those that call for the lower mental processes, measure acquired intelligence directly; but indirect measurement also is possible. Just as temperature is measured indirectly by measuring the height of the column of mercury in the thermometer, so it is possible that original intellectual capacity may be measured indirectly by means of intelligence tests.

Many statements relative to the measurement of intelligence imply that our present tests yield measures of original or native intellectual capacity, and sometimes a direct statement to this effect is made. Psychologists, however, have usually qualified their statements, especially when dealing explicitly with this point. Terman probably states their position fairly when he says: "As a matter of fact, all the 'intelligence testers' will readily agree . . . that their tests do not measure simon pure intelligence, but always native ability, plus other things, with no final verdict yet as to exactly how much the other things affect the score."[1] After careful consideration of the matter Thorndike states that "the problem of analyzing a person's intellectual ability into an amount due to nature and an amount due to nurture is unsolved. No task or test has been proved to be a measure of the former alone."[1]

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[1] Terman, L. M.—"The Great Conspiracy or the Impulse Imperious of Intelligence Tests, Psycho-Analyzed and Exposed by M. Lippman," *The New Republic*, 33:119.

**The measurement of aptitudes.**[2]—An aptitude may be thought of as capacity to learn in a particular field, such as foreign languages, mathematics, chemistry, or a vocation. Hence an aptitude test is one that measures capacity in a restricted field. An achievement test may be considered as an instrument for measuring capacity for further learning in the field of the test, but usually an aptitude test is intended to be given to persons without previous training in the field of the test. Illustrations of such tests are Wilkins Prognosis Test in Modern Languages, Hoke Prognosis Test of Stenographic Ability, and Stenquist Mechanical Aptitude Test.

Zyve[3] has reported an attempt to measure "scientific aptitude," which he analyzed into the following elements:

1. *Clarity of definition;* i. e., the ability of the student to differentiate better definitions from poorer ones, and appreciate their relative values.
2. *Suspended vs. snap judgment;* i. e., the tendency of the student to draw final conclusions from insufficient data.
3. *Experimental bent;* i. e., the tendency of the student towards experimentation.

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[1] THORNDIKE, E. L., and others.—*The Measurement of Intelligence.* New York: Bureau of Publications, Teachers College, Columbia University, 1925, p. 462.

[2] The reader who is interested in this topic will find it helpful to consult HULL, C. L.—*Aptitude Testing.* Yonkers: World Book Company, 1928. 535 pp. Chapter III describes a number of aptitude tests.

[3] ZYVE, D. L.—"A Test of Scientific Aptitude," *Journal of Educational Psychology*, 18:525–46, November, 1927.

4. *Discrimination of values in selecting and arranging experimental data.*
5. *Detection of fallacies and contradictions.*
6. *Reasoning;* i. e., not only the ability to reason according to well-established rules such as may be found in certain typical mathematical problems, but also the ability to engage, so far as possible, in original reasoning.
7. *Accuracy of systematic observations;* i. e., the ability to observe patiently and accurately by adopting some method of systematization.
8. *Induction, deduction, and generalization;* i. e., the ability of the student to use given experimental data and form correct inductions, deductions, and generalizations.
9. *Accuracy of understanding and of interpretation;* i. e., the ability to grasp the true meaning of a given body of information and to interpret it correctly.
10. *Caution;* i. e., the tendency of the student to pause to investigate before adopting a method of behavior.

A battery of tests was devised to measure these elements. Zyve reports the validity and reliability of the battery to be .82 ± .07 and .93 ± .03 respectively.

**Estimating human traits.**—A test requires that the subject respond to certain exercises which have been devised for the purpose of revealing the degree of the trait being measured. Teachers and other persons are continually estimating the intelligence of school children independently of any formal tests. They make estimates by rating pupil responses to various types of situations, few if any of which are satisfactory for testing purposes. The making of estimates is further complicated by the fact that behavior is dependent upon several factors other than intelligence. In view of these conditions, it is appropriate to inquire concerning the accuracy and validity of teachers' estimates and the procedure for making the best estimates.

Rugg,[1] writing in 1921, asserted that the rating of "human character" is not practicable "by methods so far generally employed, and probably will not be unless methods of rerating and checking judgments are carried far beyond present practical possibilities." In elaborating this statement he said: "We can predict that a single rating by a typical school officer—supervisor, superintendent, principal—will only rarely locate a person within his proper 'fifth' of the entire scale. And we can predict that a single rating on any one of the commonly used types of scales—like Elliott's or Boyce's or Beatty's or Hill's—will have a probable error of at least 10 points on a scale of 100 points and hence be practically valueless."[2]

Rugg's conclusions have not been entirely substantiated by more recent evidence,[3] and there are numerous occasions when the teacher needs to estimate the intelligence or other traits of school children. Hence there is need for considering how the best estimates may be made. Examination of rating scales reveals two general procedures —analysis of the trait to be measured in order to determine the significant characteristics and man-to-man comparison scales which tend to objectify the estimates.

An analysis of intelligence, or rather of behavior strongly influenced by intelligence, makes possible the formulation of a series of crucial questions such as: Does the pupil have a large vocabulary? Is he well informed? Does he proceed in an intelligent manner in attacking arithmetical problems? Does he exhibit originality in answering thought questions? Is he quick to understand explanations? A carefully prepared list of questions will enable a teacher to focus his attention on the significant phases of the behavior of his pupils and to make his observation more systematic. If it is desired to express the estimate in numerical form, the questions may be framed so that they can be answered in terms of points. For example, instead of asking "Does the pupil have a large vocabulary?" the question may be stated: "How large is the pupil's vocabulary?" This question may be answered in terms of points, 1, 2, 3, 4, or 5; 3 designating an average vocabulary for the pupil's age, 5 a very large vocabulary, and 1 a very meager one. The sum of the points given as answers to the questions can be used as a numerical rating of the pupil.

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[1] Rugg, Harold.—"Is the Rating of Human Character Practicable?", *Journal of Educational Psychology*, 12:425–38, November, 1921.

This article is continued in the numbers for December, 1921, and January and February, 1922.

[2] *Ibid.*, p. 426. The scales referred to are for rating teachers. The evidence for his conclusions is given in the series of articles.

[3] Watson, G. B.—"A Supplementary Review of Measures of Personality Traits," *Journal of Educational Psychology*, 18:73–87, February, 1927. In this summary Watson quotes reliability quotients from investigations of rating schemes. In several instances they are .90 and above.

The essential feature of a man-to-man comparison scale[1] is the use of definite persons as representatives of certain degrees of the trait being measured. For example, if a sixth-grade teacher desired to construct a man-to-man comparison scale for use in estimating the intelligence of his pupils he would write the name of the brightest sixth-grade pupil he had ever known at the top of the list and the name of the least intelligent pupil at the bottom. Names of other pupils would be inserted between these two to represent intermediate degrees of intelligence. A scale of five pupils is probably sufficiently elaborate. In using such a scale the teacher would com-

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[1] This scale was proposed by W. D., Scott. For a description of its use in the army, see Scott, W. D., and Clothier, R. C.—*Personal Management.* Chicago: A. W. Shaw Company, 1923, pp. 203f.

Is the characteristic relevant(?)

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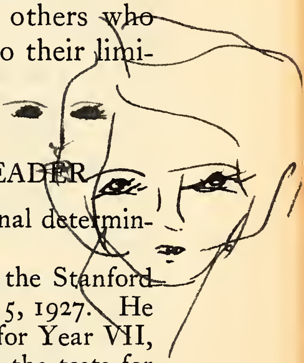
pare the pupil whose intelligence is being estimated with those of the scale and select the scale value of the one he most nearly resembled in intelligence.

**Concluding statement.**—Although this chapter is a very lengthy one, several of the topics have been treated very briefly. Hence it probably has occurred to the reader that the nature of intelligence and its measurement are not simple topics. It is relatively easy for a person to learn how to administer an intelligence test, especially a group examination, and to calculate mental ages and I.Q.'s. It is much more difficult to learn to interpret the measures obtained and to use them wisely. In this chapter the limitations of intelligence tests have been emphasized. In doing so the present writers have not intended to discourage the use of intelligence tests; they do believe, however, that teachers and others who use such tests should be informed in regard to their limitations.

End

Lucy Bowen



## LEARNING EXERCISES FOR THE READER

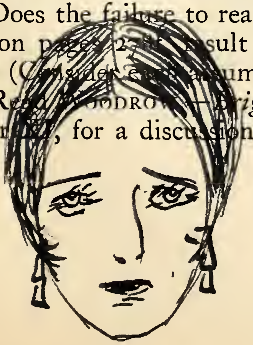
88.0
105.0

1. What is meant by the expression "educational determinism"?

2. A boy, born on April 10, 1919, was given the Stanford Revision of the Binet-Simon Scale on November 15, 1927. He passed all the tests for Year VI, five of the tests for Year VII, three of the tests for Year VIII, and failed on all the tests for Year IX. What was his I. Q.? What will probably be his mental age on his fourteenth birthday? 86 — + 11 months

3. Does the failure to realize each of the three assumptions stated on pages 27[illegible] result in constant errors or in variable errors? (Consider each assumption separately.)

4. Read Woodrow, *Brightness and Dullness in Children*, Chapter [illegible], for a discussion of various theories of mental or-



ganization. What are Woodrow's objections to Spearman's two-factor theory? What modification does he propose?

5. What is Freeman's conception of the nature of intelligence? Read Chapter XVIII in *Mental Tests*.

6. Of what significance would it be to educational theory and practice to know the extent to which one's I. Q. can be modified by training?

7. How does an aptitude test differ from an intelligence test?

8. Mention some things that would probably cause teachers to overestimate the intelligence of some pupils; some things that would probably result in their underestimating the intelligence of other pupils.

9. If it is desired to classify pupils so as to secure homogeneous groups, can this condition be secured by using the I. Q. as the basis of classification? Explain.

10. What do you regard as a defensible position with respect to the significance of the scores obtained from the use of intelligence tests?

11. Should a child know what his I. Q. is? Should his parents know? Should his schoolmates know? Should his teacher know?

12. List all the uses you can think of that could properly be made of intelligence tests.

13. With what would the scores obtained from the application of an ideal intelligence test correlate perfectly?

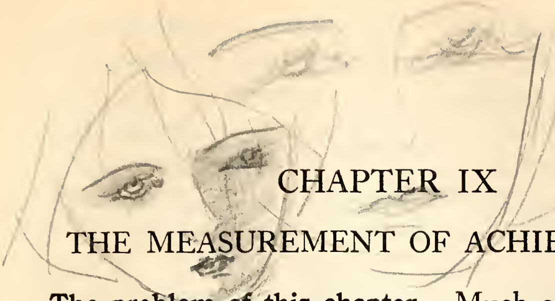
14. Do the lower animals possess intelligence? If so, how would you define intelligence so as to take cognizance of this fact?

15. Is a year's retardation in mental age equally significant at all age levels?

16. In a given grade group, what relationship should you expect to find between chronological age and I. Q.? Why?

17. Discuss the relative advantages and disadvantages of group tests and individual tests.

Read Skinner
on Intelligence



# CHAPTER IX

## THE MEASUREMENT OF ACHIEVEMENT[1]

**The problem of this chapter.**—Much of the discussion of the measurement of intelligence is also applicable to the measurement of achievement, but there are certain additional matters that should receive consideration. The central questions to be considered in this chapter are:

1. What is achievement?
2. How may achievement be measured?

**Achievement in terms of modifiable connections.**[2]—The word "achievement" is used as a name for "ability to do," or "ability to respond in appropriate ways to stimuli and situations in a given field." Achievement in a given field consists of the modifiable connections that have been established in it. "Ability to add integers" designates a group of modifiable connections. "Ability to calculate" designates a much larger group. "Ability to read silently" designates a very large group. In the case of "ability to add integers" the modifiable connections included can be specified. The list would include several hundred items, but its preparation is relatively easy. It would be considerably more difficult to specify the modifiable connections included in "ability to calculate," especially when common fractions or decimals are involved, but our present knowledge of this ability is such that a reasonably accurate list could be compiled. In silent reading the stimuli and the situations to which responses are to be made are so numerous that it would be practically impossible to prepare a detailed list of the modifiable connections included. Each word is a stimulus to which one or more meaning responses are to be made, the particular response to be made in a given case depending upon the context. Furthermore, a phrase rather than a word frequently is the stimulus, or more appropriately the situation, to which a response is to be made.

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[1] This chapter is limited to certain psychological aspects of the measurement of achievement. The reader who is interested in the topic of educational measurement should consult one or more of the available texts in that field. The point of view of the present writers is presented in Monroe, Walter S., De Voss, James C., and Kelly, Frederick J.—*Educational Tests and Measurements, Revised and Enlarged Edition.* Boston: Houghton Mifflin Company, 1924. 521 pp. For a more fundamental account see, Monroe, Walter S.—*An Introduction to the Theory of Educational Measurements.* Boston: Houghton Mifflin Company, 1923. 364 pp.

[2] The reader may find it helpful to refer to Chapter IV.

Analysis of other abilities or achievements would reveal similar conditions. When the achievement is confined to a narrow field, it is usually possible to compile a list of the modifiable connections involved; but in such cases as "ability in geography," "ability in written composition," "ability in plane geometry," and "ability in history" our present knowledge is inadequate for specifying in detail the content of the achievement. This is equivalent to saying that, in general, achievement in a school subject or a major division of it is an unanalyzed and hence indefinite group of modifiable connections.

In measuring achievement, we attempt to describe in quantitative terms the number of modifiable connections that have been established, or the strength of a group of established connections, and frequently we attempt to describe both of these things. When measuring the "ability to add integers," we are usually interested in determining the strength of the modifiable connections. In measuring "ability in history," we desire to secure information concerning the number of connections established[1] and are only secondarily interested in ascertaining the degree of their strength. In measuring "ability to read silently" we would like to ascertain both the number of connections established and the degree of their strength.

**Achievement in terms of the rubrics of controls of conduct.**—Our understanding of achievement may be increased by considering the rubrics of controls of conduct recognized in Chapter IV: (1) specific habits, (2) knowledge, and (3) general patterns of conduct. In some fields such as typewriting, spelling, or arithmetical calculation, the achievement is predominantly specific habits; in others, knowledge occupies a prominent place; and general patterns of conduct are desired as outcomes in practically all school subjects. In general, then, the measurement of the total achievement within a given field means the measurement of three types of controls of conduct. For practical purposes, however, we frequently attempt to measure only one type of controls of conduct. As a rule little attention is given to general patterns of conduct.

**Permanency of achievement.**—As the word "achievement" is commonly used, there is an implication that it represents relatively permanent controls of conduct. Studies of forgetting[2] show that modifiable stimulus-response connections tend to deteriorate if they are not exercised, especially in the case of connections only recently established. This fact has been observed by teachers who criticize the achievement of certain pupils by saying that they learn a lesson for the recitation period and then forget it. "Cramming" is used to designate a type of learning whose outcomes are largely temporary.

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[1] As used in this sentence this phrase has somewhat the same meaning as "range of information."

[2] See pages 179f.

The achievement of a pupil at a given time is not fully described unless his position on the curve of forgetting is specified. If his achievement is measured following a period of practice (exercise of the modifiable connections involved), it is certain that in the absence of continued exercise the connections will deteriorate rapidly during the following days. On the other hand, if the pupil's achievement is measured at a time several days after his last practice, the deterioration of the connections will be much less rapid during the future. Hence, a given degree of achievement means one thing if it has been preceded by a recent period of practice and another thing if it is several days or weeks removed from a period of practice.

**Achievement measured through performance.**—The kind, number, and strength of the modifiable connections that a pupil has acquired can be ascertained only by observing his responses to appropriate stimuli. A pupil's achievement can be known in no other way. It is probably true that achievement has a neural basis and that, as a pupil learns, changes take place in certain of his neurones, especially in the synaptic endings; but there is no way of identifying and measuring these changes. Consequently the process of measurement includes (1) securing an appropriate performance, that is, one which may be used as an index of the pupil's achievement, and (2) describing this response in quantitative terms. The performance is secured by means of a group of test exercises, and the description is effected by the procedure specified for scoring the test. In studying the measurement of achievement, our attention should be focused upon the nature and arrangement of the test exercises, and the plan of scoring the responses secured.

**Exercises that afford a basis for the functioning of specific habits.**—In general the exercises that afford a basis for the functioning of specific habits are those that are familiar to the pupil, i.e., those on which he has practiced. In certain fields, the pupil may not have done the particular exercises used. It is sufficient that they be similar to those on which he has practiced. For example, in addition of integers, if the pupil has practiced column addition of a given type, say exercises involving three columns and nine figures to the column, any exercises representative of this type may be used.[1] Similar illustrations could be given from typewriting, algebra, handwriting, and certain phases of other subjects.

In order to measure the rate of functioning of specific habits it is necessary that the exercises be given to the pupil in such a way that his performance can be timed. The simplest plan for doing this is to count the elapsed time from the beginning to the end of the pupil's total performance; but this procedure makes it necessary that the performance be restricted to the functioning of the specific habits being measured. For example, this means that in arithmetic the pupil should not be required to copy the test exercises from the blackboard or from the textbook.

**Exercises that afford a basis for the functioning of knowledge.**—In order to secure the functioning of knowledge, the test exercises must be such that the pupil cannot respond satisfactorily by using only specific habits. In other words, the test exercises must be *new* or such that he does not remember the response to be made. Reflective thinking is the name given to the process of using knowledge. This type of response occurs when a pupil encounters a difficulty, when he has a thought question to answer or a problem to solve. If the exercise is one for which the pupil possesses a ready-made response, that is, one which he is able to answer from memory, he is not likely to engage in reflective thinking, and consequently his performance will not be good evidence of his knowledge.

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[1] This statement implies the assumption that the exercises used for practice included all of the difficulties that arise in addition examples involving three columns and nine figures to the column.

One difficulty in the measurement of knowledge arises from the fact that a pupil's response to a problem depends upon his intelligence and certain general patterns of conduct as well as upon his knowledge. In considering the nature of intelligence in Chapter VIII, attention was called to the fact that some authorities prefer to define it in terms of ability to respond to difficulties,[1] and it is undoubtedly true that the more intelligent a pupil is, the more effective he will be in using what he knows. Furthermore, a pupil's reflective thinking is conditioned by such general patterns of conduct as scientific attitude, critical attitude, problem-solving attitude, custom of persevering, and the like.

The preceding paragraphs imply that it is difficult to secure responses that are dependable evidence of a pupil's knowledge achievement. This is true, especially when group tests are being used. In general, the teacher is likely to be in doubt concerning the extent to which the response of a given pupil represents knowledge and the extent to which it represents a remembered answer or the functioning of intelligence. It is customary to distinguish between thought questions and fact questions but it is obvious that any question becomes a fact question for a given pupil just as soon as he memorizes the answer. When a pupil answers a thought question incorrectly, the cause may be inadequate knowledge, lack of intelligence, lack of certain general patterns of conduct, or an attempt to treat it as a fact question when he does not remember the correct answer.

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[1] See page 252.

**Exercises that afford a basis for the functioning of general patterns of conduct.**—The nature of general patterns of conduct implies that no single exercise can secure evidence of this type of achievement. An essential characteristic of this type of control of conduct is a general pattern to which a pupil's responses to a variety of stimuli and situations tend to conform. Consequently, evidence of the acquisition of a general pattern of conduct can be secured only by using a series of exercises which provide an opportunity for conforming to a general pattern. For example, consider the ideal of accuracy. When completely generalized, this pattern of conduct functions as a control in any situation in which accuracy is involved—arithmetical calculation, spelling, statements of fact, measurement of magnitudes, construction activities, and the like. In order to secure evidence of the degree of generalization it would be necessary to employ a series of exercises including representatives of all types of situations in which the pattern might function. This requirement makes it difficult if not impossible to measure general patterns of conduct by means of a single formal test.

In exercises designed to secure evidence of the acquisition of specific habits and knowledge, there is a relatively direct request to which the pupil is expected to respond.

For example, if it is desired to secure evidence of his ability to add, he is requested to add. If it is desired to secure evidence of his knowledge of a topic in physics, he is asked a thought question or given a problem to solve. A significant characteristic of a general pattern of conduct, on the contrary, is that it functions when there is no direct request for conforming to the pattern. In other words, the pupil who has acquired the ideal of accuracy will endeavor to be accurate on all occasions within the field to which this ideal applies. Furthermore, he will derive satisfaction from employing procedures to attain accuracy in his responses and will be annoyed by failure to do so. The satisfaction or annoyance is a significant phase of his total response and obviously it cannot be commanded.

**The difficulty of a test exercise.**—The per cent of pupils who do an exercise correctly is taken as an index of its degree of difficulty. Since the responses that pupils make to an exercise depend upon the training they have received, it follows that the difficulty is not a characteristic that is wholly inherent in the exercise. A simple example in arithmetical calculation is considered less difficult than an intricate problem in mechanics, but the per cent of correct responses made by third-grade pupils to the example might be no greater than the per cent of correct responses made to the problem by a group of college seniors who had received extensive training in mechanics. A test exercise in history which only a small per cent of eighth-grade pupils now do correctly would become "easy" if the course in history were changed so that the exercise would be studied intensively.

The determination of the difficulty of a test exercise by having it given to a number of pupils and calculating the per cent of correct responses, is really a determination of the difficulty for pupils under present school conditions. If the instruction is modified, the degree of difficulty may be changed. Hence the difficulty of a test exercise is not a fixed characteristic but rather one that is subject to modification.[1]

**The dimensions of achievement.**—What are the significant characteristics of pupil responses? The answer to be given to this question is: (1) *rate* of responding, (2) *accuracy*, or quality of the response, and (3) the level of *difficulty* represented by the stimuli and situations to which the pupil responded. These characteristics are called *dimensions* because their relation to achievement appears to be somewhat comparable to that of length, width, and height to the volume of a parallelepiped.[2]

Recognition of these three characteristics or dimensions implies that complete measurement of achievement involves the measurement of the rate, accuracy, and difficulty of a pupil's performance. These dimensions, however, are not equally important for all types of achievement. Their relative importance depends upon the objectives in a particular field. In arithmetical calculation both rate and accuracy are usually considered important, the greater emphasis being placed upon the latter. Difficulty is considered important up to a certain point but the objectives in this field do not emphasize the ability to do harder and harder examples. In other words, it is desired that the pupil learn to do examples of moderate difficulty with a high degree of accuracy and at a fair rate. In spelling the rate of responding is minimized or even not considered. Difficulty also is not emphasized. The pupil is asked to learn to spell the most commonly used words. These vary in difficulty.

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[1] There is another aspect of difficulty which does not need to be introduced here. See Monroe, Walter S.—*An Introduction to the Theory of Educational Measurements*. Boston: Houghton Mifflin Company, 1923, pp. 110f.

[2] In making this statement the present writers do not intend to imply that rate, accuracy, and difficulty may be combined by multiplication or in some other way so as to obtain a single numerical measure of achievement similar to volume. At present there is no satisfactory formula for combining the three dimensions.

**Types of tests.**—With reference to the difficulty of the exercises, achievement tests may be classified under three types: (1) uniform test in which the exercises are approximately equal in difficulty; (2) scaled test in which the exercises vary in difficulty, usually from very easy to very difficult, and are arranged in order of increasing difficulty; (3) spiral test which consists of a group of uniform sub-tests. When the sub-tests vary in difficulty, they may be arranged so that they form a scale of increasing difficulty. Thus a spiral test may become a type of scaled test.

When we consider the information these three types of tests yield, it becomes apparent that a uniform test, if the performance is timed, yields measures of rate and accuracy—the "number of exercises attempted" in the time allowed being the rate score; and the "per cent of exercises correct," the accuracy score. In a number of cases the "number right" is used as a score, but it is obvious that it is a combination of measures of the two dimensions. A scaled test secures a performance on various levels of difficulty and hence can yield measures of this dimension. Usually the time allowed for this type of test is sufficient for each pupil to progress along the scale of difficulty as far as he is able; the number of exercises done correctly is taken as his score. This score is a combination of accuracy and difficulty.[1] If the sub-tests of a spiral test form a scale of difficulty, separate measures of accuracy and difficulty may be obtained. If the sub-tests are timed separately, a measure of rate is also yielded.

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[1] For several scaled tests a table has been prepared from which a pure difficulty score can be computed.

Tests of achievement differ with respect to the type of information they yield. It is important to recognize this fact when considering the relative merits of a group of tests in a given field. There are a number of tests designed to measure achievement in the operations of arithmetic, but all do not yield the same kind of information. If Test A is uniform and Test B is scaled, a statement that one is a better test than the other has a very limited significance. Such a statement is somewhat similar to the assertion that a certain chair is a better article of furniture than a certain table. This statement is appropriate if it is intended to mean that the chair represents better materials, superior workmanship, or a more artistic design. It is not appropriate if it is intended to mean that a person should purchase the chair rather than the table. Whether he should do this depends upon his needs. If he has plenty of chairs but no table, he should purchase the table. A similar condition prevails in choosing a test. If a teacher desires a difficulty score he should select a scaled test. If he desires measures of rate and accuracy he should select a test that yields measures of these dimensions.

**The relation of achievement to performance.**—The measurement of achievement by measuring performance implies that performance and achievement are related in such a way that the former may be taken as a dependable index of the latter. The situation is similar to that which exists in measuring temperature by means of a thermometer. Temperature is measured by measuring the height of a column of liquid. Experience has demonstrated that within the ordinary range of temperature these two things are related in such a way that the height of the liquid in a thermometer may be taken as a dependable index of temperature. Unfortunately, performance and achievement are not related in a way such that the former is a highly dependable index of the latter. The indirect measurement of achievement by measuring performance is, under the best conditions, only moderately satisfactory, and frequently is distinctly unsatisfactory. The justification of this statement will be more apparent in the following pages.

**Factors affecting pupil performances.**—The measurement of achievement is made difficult by the fact that a pupil's response to a group of test exercises is affected by a number of factors other than his achievement.[1] Some of the more significant factors are: (1) the pupil's acquaintance with testing conditions—especially the type of test being used; (2) the pupil's present frame of mind, or mind-set; (3) the effort the pupil makes; (4) distractions such as noises, activities of other pupils, interruptions, etc; (5) the pupil's interpretation of the test exercises; (6) the pupil's physical condition; and (7) the pupil's emotional status. The first of these factors is usually referred to as practice effect. When a duplicate form of a test[2] is administered within a few days after the first form was given, the scores on the second test will usually be higher. For some types of tests the increase is in the neighborhood of ten per cent, but the practice effect varies.[3] The other factors do not need comment. It is obvious from the discussion of Chapter V that they will affect the pupil's performance. Extreme variations in these factors will produce significant variations in the performances, but the effect of minor variations is not large.

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[1] See the description of the factors that affect learning activity, pages 220f.

[2] A duplicate form of a test consists of exercises similar in type and difficulty but the exercises are different.

[3] For practice effects on intelligence tests see page 284.

**The zero point of measures of achievement.**—The measures of achievement yielded by a test are expressed usually in terms of a scale whose zero point is arbitrary. A score of zero does not mean zero achievement. In many cases a pupil might be unable to do a single exercise correctly and yet possess some ability in the field of the test. For example, if a spelling test designed for the eighth grade were administered to fourth-grade pupils, a considerable number would probably be unable to spell a single word correctly. It is obvious, however, that a zero score on such a test would not necessarily signify zero spelling ability. In addition to being arbitrary, the zero point of an achievement test is seldom defined—that is, the degree of ability it represents is not known.

**Measures of achievement interpreted by comparison with norms.**—The scores yielded by a test are interpreted by comparing them with the norms or standards established for the test. The most commonly used norms are the average or median scores of the grade groups to which the test is intended to be administered. For example, the grade norms for a test designed to be used in grades III, IV, and V would be the average or median of the scores obtained by administering it to a large number of typical classes in each of these grades.[1] A norm of this type provides a basis for interpreting the score of a pupil with reference to the average for his grade. For example, if the norm is 36, a score of 40 indicates a degree of achievement somewhat higher than the average achievement in the pupil's grade; a score of 30 indicates a degree of achievement lower than the average.

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[1] Norms can be and sometimes are established in other ways, but this method is the one commonly used.

**Maintenance of standard testing conditions implied in the interpretation of scores.**—Since scores are affected by the conditions under which the tests are given, a complete statement of a norm includes specifications in regard to testing conditions. A norm is *not* the average of the scores obtained by administering the test in any way that the examiner might prefer at the time, but it is the average of the scores obtained when the test is administered under certain conditions. Some of these testing conditions are prescribed in the directions accompanying the test, but others are assumed. For example, it is assumed the pupils have not been coached for the test, that they will make a reasonable effort to do the exercises, that their mental set is not inconsistent with the test, and that their emotional status is not such that it operates as a handicap. Consequently the comparison of a pupil's score with a norm implies the assumption that the pupil has been tested under standard conditions—that is, under the testing conditions for which the norm was established.

**Measurement by means of sampling.**—When an attempt is made to measure a large segment of achievement—such as ability to spell, ability in silent reading, or ability in physics—it is not possible to provide for the functioning of all of the modifiable connections that have been established. When this is the case, the achievement is measured by sampling. This is satisfactory, provided the sample taken is representative. Many commodities are bought and sold on the basis of sample measurements. For example, it is not feasible to test an entire carload of wheat for quality; hence only a small sample is measured.

Cream is measured for butter fat by taking a very small sample. It should be noted, however, that in such cases a procedure is followed which will insure that the sample will be representative. When achievement is measured by sampling, the procedure should be such that the sample secured will be representative not only of the specific habits but also of the knowledge and general patterns included in the achievement in question.

**Measurement of what a pupil has learned versus measurement of the extent to which he has achieved the objectives of the school.**—In the preceding paragraph it was asserted that measurement by sampling is satisfactory if the sample is representative, but there was no specification as to whether it should represent what the pupil has learned in the field, or the objectives set by the school. The difference between these two bases of sampling may be illustrated in spelling. A representative sample of the words a pupil has learned may be, and probably will be, different from a representative sample of the words that the school desires him to learn. For most purposes we desire to know the extent to which pupils have achieved the objectives set for them rather than the controls of conduct they have acquired without regard to the objectives of the school. Consequently the sample taken is usually intended to be representative of the objectives rather than of the controls of conduct acquired.

It may be noted that in order to have the sample representative of what each pupil has learned, a different sample would be required except when two or more pupils had formed the same S→R connections. In view of the individual differences that exist,[1] it would be necessary to take a large number of different kinds of samples in measuring the achievements of a typical class.

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[1] See Chapter X.

**Assumptions upon which measurement of achievement by means of standardized tests is based.**[1]—The preceding discussion has emphasized the fact that the measurement of achievement by means of standardized tests[2] is based upon certain assumptions which are only approximated under the best conditions. These assumptions have been suggested in the preceding pages, but it will be worth while to state them more definitely at this place. Some of them depend upon the character of the measuring instruments; some of them are introduced by reason of group measurements; others depend upon the use of common norms for the interpretation of all measures yielded by a given measuring instrument. The second and third assumptions listed on pages 279–80 are also applicable to the measurement of achievement.

1. *It is assumed that achievement is a relatively stable acquired trait of the pupil and is not subject to marked fluctuations from hour to hour and day to day.* Achievement does change. If an ability is not exercised, it deteriorates, the deterioration being especially rapid immediately after a period of exercise.[3] Consequently, this assumption is only approximately true. If a test is given soon after a period of practice, the results may be very misleading.

2. *It is assumed that the performance sustains a constant functional relation to the ability which is being meas-*

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[1] This discussion is based on Monroe, W. S.—*An Introduction to the Theory of Educational Measurements.* Boston: Houghton Mifflin Company, 1923, pp. 21f.

[2] Standardized tests have norms or standards which are used in interpreting the scores of pupils.

[3] See pages 179f.

*ured.* This assumption is implied in the use of common norms for the interpretation of all measures yielded by a test. For example, if the norm of a given test for the fourth grade is 17, the scores of all fourth-grade pupils are interpreted by comparison with this norm. This is done even though the test is administered by different examiners at different places and at different times. This assumption means that any change in ability from pupil to pupil produces a proportional change in the performances, and that all variations in performances are produced by corresponding changes in ability. Since a pupil's performance is affected by several factors,[1] it is obvious that this assumption is only approximately true, even when an earnest attempt is made to control testing conditions. Any marked departure from the prescribed testing conditions is likely to change the functional relation between the performance and the achievement; consequently the scores will be misleading if interpreted by comparison with the norms.

3. *It is assumed that the performance is the product of the functioning of certain mental processes or abilities and no others—at least not in a way to disturb the constant functional relation.* This assumption is implied in the one just mentioned above. In case the performance is to sustain a constant functional relation to a given ability, it is obvious that this performance must not be affected by other abilities unless the contributions of these other abilities are synchronized with the fluctuations produced by the ability being measured. Generally speaking, different abilities are sufficiently independent so that their contributions do not correlate perfectly. It is desirable that the performance secured be the product of

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[1] See page 314.

the functioning of the abilities being measured and no others.

A problem test in arithmetic requires ability to read. Consequently, if the pupils tested are not approximately equal in reading ability, their performances will be affected by differences in this ability, especially if the test is timed to secure a measure of rate. The performances on a test that requires much writing will be influenced by the rate of writing. Hence it appears that this assumption is not always true. When this is the case, care must be exercised in interpreting the scores obtained.

4. *It is assumed that the test affords each pupil a reasonable opportunity to demonstrate his ability in the field being measured.* This assumption is important when achievement is measured by sampling.[1] A sample is a valid index of the whole only when it is representative. If the whole is homogeneous, and the sample is random, it will be representative. If the whole is not homogeneous, and a random sample is taken it will not be representative except by chance.

Most of our tests measure achievement by sampling. Achievement in arithmetical calculation and in some other fields usually approaches homogeneity; but in silent reading, spelling, history, physics, and a number of other school subjects pupil achievement is not usually homogeneous. Furthermore, what a pupil has learned is seldom, if ever, distributed uniformly over the field. For example, in spelling, a pupil has learned some words so that he always spells them correctly; he spells other words correctly sometimes; and he has not learned other words at all. The distribution of achievement is likely to be different for different pupils. Consequently, a given sample performance may not be representative for some pupils and is almost certain not to be representative for a few, especially if the sample is small. This fact has been observed by many who have taken standardized tests, and they have criticized the tests by pointing out that some of the exercises related to topics they had not studied. In such cases a pupil in demonstrating his achievement does not have an opportunity commensurate with the opportunity that is afforded the pupil who has studied all of the topics included.

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[1] See pages 316–17.

**Effect of failure to conform to assumptions.**—The preceding discussion has been critical, and the reader may have reached the conclusion that the measurement of achievement by means of standardized tests rests upon such an uncertain foundation that the scores obtained seldom approximate accurate measures of the abilities whose measurement is being attempted. There is some justification for such a belief when individual scores are considered, and it is important that a person who uses standardized tests be aware of their limitations; experience with these measuring instruments indicates, however, that when an honest effort is made to control testing conditions, the scores obtained will be reasonably accurate measures. A few will involve relatively large errors, but most of them will be sufficiently accurate for most purposes.

The intelligent user of standardized tests keeps in mind the difficulties involved in the measurement of achievement. Consequently he is aware that, in general, test scores involve very much larger errors than measures of height, weight, and the like, and that some scores are grossly inaccurate. On the other hand, he does not condemn all standardized tests as worthless and assert that it is impossible to measure achievement.

**Objective description of performances.**—In describing the process of measurement two phases were recognized—(1) securing an appropriate response, and (2) describing this response in quantitative terms. It is a well-known fact that when several persons in a group are asked to estimate physical magnitudes—such as the length of a stick or the weight of a stone—their estimates will vary widely. A similar result is obtained when a group of competent teachers grade an examination paper of the traditional or essay type.[1] This condition is designated by the word "subjective." It means that an estimate depends upon the person making it. The opposite condition is designated by the word "objective" which means that the estimate is relatively independent of the person making it, and hence that a group of persons will give the same or very nearly the same quantitative description.

Objective measurement of achievement is secured by devising the test in such a way that the pupil's response may be described according to explicit rules that do not permit the exercise of judgment by the one describing it. This condition usually exists in marking a spelling paper, the description of the pupil's response being given in terms of the number or per cent of words spelled correctly. Barring actual errors on the part of the scorer, the same score would be assigned by all who might rate the paper. In arithmetic and in factual phases of other subjects the exercises commonly used are such that competent persons usually make the same evaluation of pupil responses.

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[1] One of the first investigations of grading examination papers was by Starch and Elliott who found that the marks assigned to the same paper in plane geometry by 116 teachers ranged from 28 to 92 on the scale of 100 per cent. More striking evidence of the subjectivity of the marking of examination papers is cited by a more recent writer. One of a group of expert readers, assigned to the marking of a set of examination papers for a large college class in history, after scoring a few of them wrote out for his own convenience what he considered to be model answers to the questions. By some mischance this "model examination paper" fell into the hands of another expert reader who graded it as a paper written by a student. The mark which he assigned to it was below passing and according to the custom it was also rated by other expert readers with the result that the marks assigned to it by these readers varied from 40 to 90. There have been many investigations of the Starch-Elliott type and all of them have corroborated the findings of the first investigators.

For typical investigations see: Starch, Daniel, and Elliott, E. C.—"Reliability of Grading Work in Mathematics," *School Review*, 21:254–59, April, 1913. Morton, R. L.—"The Examination Method of Licensing Teachers," *Educational Administration and Supervision*, 6:421–32, November, 1920. Wood, B. D.—"The Measurement of College Work," *Educational Administration and Supervision*," 7:301–34, September, 1921. Kelly, F. J.—"Teachers' Marks," *Teachers College, Columbia University, Contributions to Education*, No. 66. New York: Bureau of Publications, 1914, pp. 51–84.

In order to make the scoring of test papers objective, test-makers have exhibited much ingenuity in devising exercises of such a nature that definite rules can be prescribed for evaluating the pupil responses. One general plan is to limit the pupil to making one of two or more specified responses. For example, in what is called the true-false exercise, the pupil is restricted to the two responses, "true" and "false." He is not permitted to make any other. In a multiple-choice exercise the pupil is given several specified responses, usually four or five, from which he is permitted to choose one. In a completion exercise, the pupil is usually free to write in any word or phrase that he believes is correct, but the omissions from the original statement are intended to be such that only one response can be considered correct.

In general, the principle of objective measurement is that the test exercises be constructed so that there is only one response that is correct. This requirement is satisfied in arithmetical calculation and spelling. The so-called "new examination" represents an attempt to extend this principle to other fields of achievement.

**Scales used in describing rate and accuracy of pupil responses.**—The rate of a pupil's response is commonly described in terms of the number of exercises or other units of the test done within the time allowed for it.[1] For example, in the Courtis Standard Research Tests in Arithmetic, Series B, the pupils are allowed eight minutes in which they are expected to do as many of the addition examples as they can. The "number of examples attempted" is used to describe the rate of their responses. In the Monroe Standardized Silent Reading Tests, Revised, the time is four minutes and the rate score is the "number of words read per minute." The rate of handwriting is described in terms of the "number of letters per minute."

The quality of pupil responses that may be classified as "right" or "wrong" is usually described in terms of the "number right" or the "per cent right." For example, in the Courtis Standard Research Tests in Arithmetic, Series B, the accuracy score is the "number right." In the Monroe Standardized Silent Reading Tests, Revised, the comprehension score is the "number of exercises answered correctly." Both of these scores really are a combination of "rate" and "accuracy," and the quality of the responses would be described more truthfully by the "per cent right."

**Descriptions of quality in quantitative terms.**—When a pupil's performance or some division of it cannot be described as right or wrong, it is necessary to construct a scale that can be used in describing its quality. This condition exists in handwriting, English composition, handsewing, and drawing. A quality scale is simply a collection of sample performances of the type to be described, exhibiting varying degrees of quality from the lowest quality with which we have to deal up to the highest such quality. The samples are arranged in order of increasing quality, and usually the quality of each is described numerically. It is desirable to have the samples selected so that the differences in quality between successive samples are approximately equal. It is also desirable to have the numerical designations of the degrees of quality express the amount of quality measured from a zero which means no quality at all.

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[1] When this is done it is assumed that the time allowed for the test is short enough so that very few if any pupils complete it.

A quality scale of this type is used by matching the performance to be described with the sample of the scale which most nearly resembles it in quality. The decision which the scorer reaches is only an opinion, and we find that different persons match the same performance with different scale samples. The matching is, therefore, a subjective process; i.e., it depends upon the person who does it. Appropriate training will materially reduce the subjectivity of the process.[1]

**Scales of difficulty.**—The difficulty of an exercise depends upon the training of the pupils[2] as well as upon the nature of the exercise, but it is customary to speak of the difficulty[3] of an exercise as if it were an intrinsic characteristic.

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[1] THORNDIKE, E. L.—"Teachers' Estimates of the Quality of Specimens of Handwriting," *Teachers College Record*, Vol. 15, No. 5. November, 1914, 13 pp.

GRAY, C. T.—"The Training of Judgment in the Use of the Ayres Scale for Handwriting," *Journal of Educational Psychology*, 6:85–98, February, 1915.

[2] See page 310.

[3] Difficulty has been defined as that characteristic of an exercise which, when present in a large degree, causes a large per cent of incorrect responses; and, when present in a small degree, is accompanied by a small per cent of errors. In other words, the degree of difficulty of an exercise is determined by the per cent of correct responses obtained when it is given to a large number of pupils. If certain assumptions are made concerning the distribution of the ability of

A scale of difficulty as the term implies consists of exercises or groups of exercises ranging in difficulty from very easy to very difficult and arranged in order of difficulty, the first ones being so easy that practically all pupils can do them correctly. Such a scale is sometimes called a *power test.*

**Comparison of achievement with intelligence.**—For many purposes it is more significant to know the relation of a pupil's achievement to his intelligence or capacity to achieve than to know merely the magnitude of his achievement. Test-makers have proposed several procedures for such a comparison. The one most widely used is the ratio of achievement (measured in terms of achievement age) to intelligence (measured in terms of mental age). Two names are applied to this ratio[1]—Achievement Quotient and Accomplishment Quotient—but both are represented by the symbol A.Q. The method of calculating the A.Q. is such that the pupil whose achievement is commensurate to his intelligence receives an A.Q. of 100; one whose

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the pupils to whom an exercise is given, and the zero point is located, the degree of difficulty of the exercise can be expressed in terms of a unit of variability of this distribution of ability. This unit is the difference in difficulty between two exercises which are answered correctly by certain per cents of a given group of pupils. The median deviation or probable error (P. E.) is frequently used as a unit. It is defined as the difference in difficulty between an exercise which is answered correctly by 50 per cent of the pupils, and an exercise which is answered correctly by 25 per cent of the same pupils. The standard deviation (S. D. or $\sigma$) is also used as a unit. It is the difference in difficulty between an exercise answered correctly by 50 per cent of the pupils and an exercise answered correctly by 15.87 per cent of the same pupils. Thus, we describe the difficulty of exercises as being 2.7 P. E., 6.3 P. E., 5.2 $\sigma$., etc. For further details see MONROE, WALTER S.—*An Introduction to the Theory of Educational Measurements.* Boston: Houghton Mifflin Company, 1923, pp. 92f.

[1] The first published report of the use of this ratio was in connection with the Illinois Examination, a battery of three tests—Illinois General Intelligence Scale; Monroe Standardized Silent Reading Test, Revised; Monroe General Survey Scale in Arithmetic. See MONROE, WALTER S.—"The Illinois Examination," *University of Illinois Bulletin*, Vol. 19, No. 9, Bureau of Educational Research Bulletin No. 6. Urbana: University of Illinois, 1921. 70 pp.

achievement is less than that of the average pupil of his intelligence receives an A.Q. of less than 100; and one whose achievement is greater than that of the average pupil of his intelligence receives an A.Q. greater than 100.

The significance of an A.Q. is apparent. Pupils differ in intelligence or capacity to learn. Hence for some purposes an achievement score of 47 made by a pupil whose mental age is ten years should be interpreted differently from an achievement score of 47 made by another pupil whose mental age is thirteen years. The first pupil may have learned more than the average for his degree of intelligence while the second has failed to do satisfactory work. It should be noted, however, that the A.Q. is subject to greater errors than test scores[1] and hence caution should be exercised in using the A.Q. with individual pupils.[2]

**Two faults of measures of achievement.**—One fault or limitation of measures of achievement is due to the fact that in many cases the responses secured are not direct and unmixed evidence of the achievement being measured. For example, in measuring what is commonly called "ability to read," it is necessary to secure a response different from normal reading. The pupil is asked to read certain material—usually short paragraphs which do not represent continuous discourse—and also to answer certain questions about what he has read. It is obvious that the pupil's response is not typical reading. It is reading mixed with other responses.

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[1] The errors in intelligence-test scores were considered on pages 282f. Achievement-test scores are subject to similar errors.

[2] For a comprehensive treatment of the A. Q., see ODELL, C. W.—"A Critical Study of Measures of Achievement Relative to Capacity," *University of Illinois Bulletin*, Vol. 26, No. 29, Bureau of Educational Research Bulletin No. 45. Urbana: University of Illinois, 1929. 58 pp.

Some tests claim to measure knowledge—i.e., the ability to respond to new situations—by measuring information or the store of memorized facts. In other words, measurement of certain types of achievement is attempted by indirect methods.

The use of indirect methods of measurement and of exercises that call for responses representing a mixture of the functioning of the achievement it is desired to measure and the functioning of other achievements, results from our need to secure responses that are observable and ones whose description is relatively easy. Conformity to this basic requirement results in the introduction of a significant fault in many measures of achievement. For example, the scores yielded by the Monroe Standardized Silent Reading Tests, Revised, are labeled measures of rate and of comprehension, which are interpreted to mean "measures of the rate of normal reading" and "measures of the degree of comprehension when reading typical material." Strictly speaking, these scores are not such measures. The rate score is a measure of the rate of doing certain exercises that involve reading unconnected material and answering certain types of questions. The comprehension score is a measure of the rate and accuracy of answering the same types of exercises.

When a score yielded by a test is given a label not strictly in accord with its true nature, there is a chance that it is not a truthful or valid measure of the achievement specified by the new label. In other words, it may be lacking in *validity*.

When test scores are considered under their true labels, they are seldom accurate. This condition is shown when the test, or a duplicate form of it, is administered a second time to the same group of pupils. A few pupils will make equivalent or nearly equivalent scores, but in most cases the scores will be different. If we assume that the achievement of the pupils has remained constant, it is obvious that in the cases in which the two scores are not equivalent, one or both of the scores are inaccurate.[1] This fault of measures of achievement is commonly considered under the head of *reliability*.[2]

**Constant errors in measures of achievement.**—In addition to the two faults or limitations described in the preceding paragraphs, measures of achievement are also subject to constant errors. The most common cause of constant errors is acquaintance with the test or with the testing procedure.[3]

**Standardized tests available for school use.**—A standardized test is one for which norms or standards have been determined. The number of such tests now available for school use is large and new ones are constantly appearing. Consequently, it is impossible to include a list of available tests in this volume. A reader who is interested in learning about the achievement tests that should be considered when one is to be selected for use, should consult an up-to-date text on the subject.[4]

**Measurement of achievement by unstandardized tests.**—Achievement may be measured by tests that have not been standardized. In fact, most of the measuring of achievement is done by tests or examinations constructed by the teacher. Most of the preceding discussion applies to such measuring instruments as well as to standardized tests. This is especially true of the discussion of the nature of achievement and the assumptions implied by the methods of measurement employed. By observing so far as possible the principles recognized by makers of standardized tests, teachers will secure more satisfactory measures of achievement.[1]

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[1] See pages 285f. for a description of the methods employed for obtaining an index of the variable errors of measurement.

[2] The discussion of the reliability of intelligence-test scores on pages 285f. is also applicable to measures of achievement. In general the variable errors in achievement-test scores are larger than those in measures of intelligence.

[3] See the discussion of constant errors on pages 283–85.

[4] A very useful list of standardized tests is given by KELLEY, T. L.—*Interpretation of Educational Measurements*. Yonkers, N. Y.: World Book Company, 1927, pp. 288–348.

**The measurement of personality traits.**[2]—The term "personality traits" is used as a name for a number of mental traits that are possibly determined in a larger degree by heredity than are such achievements as ability in reading, proficiency in handwriting, knowledge of physics, and the like. Hence the measurement of personality traits might properly have been included in the preceding chapter. It has seemed desirable, however, to treat the topic as one phase of the measurement of achievement, since a number of personality traits are essentially general patterns of conduct.

The discussion of the types of exercises that afford a basis for the functioning of general patterns of conduct[3] suggests a fundamental difficulty in the measurement of personality traits. It is relatively easy to devise test exercises to secure performances indicative of specific habits and knowledge. It is much more difficult to devise test exercises that will secure a functioning of personality traits, and the performances secured will seldom be satisfactory for measurement purposes. This difficulty is due in part to the fact that we do not, as yet, have precise definitions of the traits to be measured; but if such definitions were available, it would still be difficult to devise satisfactory test exercises. Measurement of a given achievement by means of a formal test implies that the functioning of the achievement can be secured upon demand, and that the performance given is not influenced by other achievements, at least not to a degree that makes resulting measures unsatisfactory.[1] Furthermore, the performance secured must be such that it can be described objectively.

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[1] New-type tests represent an attempt to observe certain principles of test construction. For a comprehensive discussion of these measuring instruments see ODELL, C. W.—*Traditional Examinations and New-Type Tests.* New York: The Century Company, 1928. 469 pp.

[2] For excellent summaries of the attempts to measure personality traits see ALLPORT, G. W.—"Personality and Character," *Psychological Bulletin*, 18:441–55, September, 1921.

SYMONDS, P. M.—"The Present Status of Character Measurement," *Journal of Educational Psychology*, 15:484–98, November, 1924. The second of these references describes eight methods of measurement.

WATSON, G. B.—"A Supplementary Review of Measures of Personality Traits," *Journal of Educational Psychology*, 18:73–87, February, 1927. This reference gives a summary of the findings of a number of investigators. They are stated in the form of twenty-five principles.

[3] See page 309.

In spite of these difficulties test makers in this field are making progress. A large number of ingenious tests have been devised.[2] It would not be appropriate to attempt a description of all of these tests in this volume, and the following pages are intended merely to suggest to the reader what is being done in this field of measurement.

The number of personality traits has not been determined, but in discussing their measurement, Freeman[3] groups the tests under four heads: (1) will-temperament;

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[1] See page 319.

[2] A number of tests and other means of measuring personality traits were employed in the studies of gifted children directed by L. M. Terman. See TERMAN, L. M.—*Genetic Studies of Genius*, Vol. I. Stanford University: Stanford University Press, 1925, Chapters XIII, XIV, XV, XVI, XVII, and XVIII.

[3] FREEMAN, F. N.—*Mental Tests*. Boston: Houghton Mifflin Company, 1926, p. 192.

(2) emotional temperament; (3) moral disposition; (4) æsthetic sensibility.

1. *Will-temperament.*—The trait or traits under the head of will-temperament determine or are influential in determining those characteristics of behavior which we designate by such words as energetic, cautious, timid, phlegmatic, reckless, persistent, and vacillating. Downey, whose tests are the most widely known and the most elaborate of those devised to measure will-temperament, groups the traits of will-temperament under three characteristics of reaction: (1) speed and fluidity; (2) forcefulness and decisiveness; (3) carefulness and persistence.[1] The source of these traits is in the "amount of nervous energy at the disposal of the individual" and "the tendency of such nervous energy to discharge immediately into the motor areas that innervate the muscles and glands; or, on the contrary, to find a way out by a roundabout pathway of discharge."[2] In measuring will-temperament, Downey requires the pupil to write simple expressions under a variety of conditions. In this way she secures evidence of the effect the pupil's traits have upon his behavior, which is represented by handwriting. Altogether there are twelve tests, only three of which are not based on handwriting. Originally the tests were designed to be used in testing pupils individually, but they have been adapted to group use. The reliability of the separate tests has been found to be fairly high, some of the coefficients being above .80.[3]

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[1] Downey, J. E.—*The Will-Temperament and Its Testing.* Yonkers: World Book Company, 1923, p. 62.

[2] *Ibid.*, p. 59.

[3] Downey, J. E., and Uhrbrock, R. S.—"Reliability of the Group Will-Temperament Tests," *Journal of Educational Psychology*, 18:26–39, January,

2. *Emotional-temperament.*—Emotional-temperament, as the term implies, includes traits that are closely related to the emotions. The effect of such traits is primarily subjective; but usually there are observable manifestations, so that a trained observer can classify many persons as pessimistic or optimistic, enthusiastic or apathetic, and the like. Attempts have been made to measure the traits that make up emotional-temperament indirectly by asking the subject to designate the emotion that he experiences when he reads or thinks of certain words. Pressey[1] has devised a test on this plan to measure the emotions, but it probably represents little more than a beginning and would be of little value to one who had not had training in psychological testing.

3. *Moral disposition.*—The traits included by Freeman under "moral disposition" are essentially certain general patterns of conduct[2] and therefore would be classed as acquired rather than native. Aspects of behavior accredited to the influence of these traits are indicated by such words as honest, truthful, charitable, obedient, helpful, and considerate. Some investigators have attempted to measure certain moral traits by asking the subject to pass judgment regarding right and wrong conduct, but it appears that more satisfactory results may be secured by placing the subject in certain situations and noting whether his behavior conforms to the general pattern. A test of the second type has been employed by

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1927. See also Downey, J. E.—"Observations on the Validation of the Group Will-Temperament Test," *Journal of Educational Psychology*, 18:592–600, December, 1927.

[1] Pressey, S. L.—"A Group Scale for Investigating the Emotions," *Journal of Abnormal Psychology*, 16:55–64, April, 1921.

[2] See pages 138f.

Voelker,[1] who desired to measure trustworthiness. Among the situations in which the subjects were placed was the purchase of an article and the receipt of more change than was due. Evidence of the subject's behavior was secured by requiring him to give the change to the examiner. If the amount turned over included the ten cents over-change or if the boy had returned it to the merchant, his behavior was in conformity with the general pattern of trustworthiness. If he kept the ten cents it was not.[2]

Woodrow[3] has reported an attempt to secure measures of character by asking children to tell which pictures in certain groups they liked best. "Each picture shows one or more boys or girls doing something, and was drawn with the idea of depicting an act in a child which would ordinarily be regarded by an adult as either 'good' or 'bad.'" With one exception the pictures of a group were intended to illustrate four degrees of a certain trait. Although this attempt to measure character must be regarded as having not advanced beyond the experimental stage, it is a good illustration of the ingenuity that investigators are exhibiting in attempting to measure personality traits. Another interesting device is a questionnaire proposed by Symonds[4] to measure "studiousness or like for school work." In the questionnaire the pupil is asked to express his like or dislike for various things, and from the responses a score is computed which is used as an index of his liking for school work.

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[1] Voelker, P. F.—"The Function of Ideals and Attitudes in Social Education," *Teachers College, Columbia University Contributions to Education*, No. 112. New York: Bureau of Publications, Columbia University, 1921. 126 pp.

[2] For a report of an attempt to measure "attitude toward cheating" see May, M. A., and Hartshorne, Hugh.—"First Steps Toward a Scale for Measuring Attitudes," *Journal of Educational Psychology*, 17:145–62, March, 1926.

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[3] Woodrow, Herbert.—"A Picture-Preference Character Test," *Journal of Educational Psychology*, 17:519–31, November, 926.

Turner

[4] Symonds, P. M.—"A Studiousness Questionnaire," *Journal of Educational Psychology*, 19:152–67, March, 1928.

4. *Æesthetic sensibility.*—Very little has been done toward measuring traits of æsthetic sensibility. Freeman[1] states that he had found only two reports of attempts—a test of æsthetic appreciation of form and design and of poetry by Thorndike; and a test of æsthetic appreciation of pictures by Cattell, Glascock, and Washburn.

**The measurement of other traits.**—There are a number of tests that do not appear to be classifiable under the headings employed by Freeman. The A-S Reaction Study by Allport and Allport[2] represents an attempt to measure "the disposition of an individual to dominate his fellows (or to be dominated by them) in various face-to-face relationships of every-day life." The test is essentially a questionnaire which asks the subject to tell how he habitually performs in a number of situations. The Laird Personal Inventory[3] represents a somewhat similar instrument, but most of the situations are different. Moss, Hunt, Omwoke, and Ronning have devised a Social Intelligence Test.[4] The combination of traits it is intended to measure is indicated by the titles of the subtests: (1) Judgment in Social Situations, (2) Memory for Names and Faces, (3) Recognition of Mental States from Facial Expressions, (4) Observation of Human Behavior, (5) Social Information, (6) Recognition of the Mental State of the Speaker. Wyman has developed a free-association test for measuring "intellectual, social, and activity interests" of school children.[1]

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[1] Symonds, *op. cit.*, p. 223.

[2] Published by Houghton Mifflin Company.

[3] Published by Hamilton *Republican*, Hamilton, New York.

[4] Published by Center for Psychological Service, 2024 G Street N. W., Washington, D. C.

These tests are but samples of a number that have been proposed. Some of them are obviously crude, and probably all of them should be considered as being in the experimental stage. They are, however, indicative of the interest in this field of measurement.

**The measurement of traits by rating scales.**—Several workers have attempted to measure certain traits by employing a rating scale as an aid in forming estimates. Hughes[2] has prepared a scale for rating separately twenty-two traits, which he classifies under the general title, "Capacities, Attitudes, and Interests." The scale is accompanied by descriptions of the highest and lowest ranks of each of the first twelve of the traits. The other ten, which are designated as "Special Interests," are described more briefly.

Among the devices for increasing the accuracy of the ratings is that of increasing the number of items. This appears to produce an effect similar to that obtained by having independent ratings made by two or more judges and using the average.[3] Freyd[4] recommends the use of an instrument for rating which consists of a number of carefully selected questions each of which is provided with a "graphic scale" for answering.

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[1] Wyman, J. B.—"Tests of Intellectual, Social, and Activity Interests," *Genetic Studies of Genius*, Vol. I. Stanford University: Stanford University Press, 1925, pp. 455–83.

[2] Hughes, W. H.—"A Rating Scale for Individual Capacities, Attitudes, and Interests," *Journal of Educational Method*, 3:56–65, October, 1923.

[3] Furfey, P. H.—"An Improved Rating Scale Technique," *Journal of Educational Psychology*, 17:45–48, January, 1926.

[4] Freyd, Max.—"The Graphic Rating Scale," *Journal of Educational Psychology*, 14:83–102, February, 1923.

Knight[1] found that "length of acquaintance" influences ratings, and that extended acquaintance makes the ratings too lenient, and less critical and analytical. "It is in the direction of truth to discount the ratings of judges when acquaintance has been long. In a way it is literally true to say of a judge's estimate: 'His judgment is of doubtful validity *because* he has known his man *too long.*'"[2]

**The status of the measurement of personality traits.**—The measurement of personality traits has not yet reached a satisfactory stage of development. Many of the instruments developed are not sufficiently simple for a teacher to use, except for case studies, and the measures secured are so unreliable that their usefulness is limited; but probably the most serious criticism is that as yet we have only very vague ideas of the traits we are attempting to measure. On the other hand, it does not seem reasonable to doubt either the existence of some personality traits, or their influence in determining behavior. It is important, therefore, for the teacher to become familiar with such devices as will be useful in estimating these traits, or in making more objective measures of them.

## LEARNING EXERCISES FOR THE READER

1. What is the physical basis of achievement? In what sense are all educational measurements indirect? In what different sense are some educational measurements indirect?
2. List ten reasons why an obtained measure of achievement may not be an accurate measure of ability in the field in question.
3. What appear to be the chief weaknesses of ordinary

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[1] KNIGHT, F. B.—"The Effect of the 'Acquaintance Factor' upon Personal Judgments," *Journal of Educational Psychology*, 14:129–42, March, 1923.

[2] *Ibid.*, p. 142.

school-room examinations as instruments for measuring achievement?

4. Generally speaking, are measures of achievement to be regarded as absolute or relative? What bearing does the absence of true zero points on the scales of measurement have on this question?

5. What are the characteristics of a good test or examination? See Ruch, G. M.—*The Objective or New-Type Examination*. Chicago: Scott, Foresman and Company, 1929, Chapter II.

6. Explain the difference between intensive and extensive sampling, using Figures 2 and 3, on pages 58 and 59, in the reference just cited. Which is preferable? Why?

7. What is meant by "controlling testing conditions"? Does failure to control result in constant errors or in variable errors, or in both? Explain.

8. Is the measurement of temperature by means of a thermometer, or the measurement of air pressure by means of a barometer, objective or subjective? Explain.

9. What purposes is the A. Q. designed to serve?

10. Become acquainted with the available standardized tests in the subject or subjects you teach. Consult Smith, H. L., and Wright, W. W.—*Tests and Measurements*. New York: Silver, Burdett and Company, 1928. 540 pp.

11. What advantages over teacher-made examinations do standardized tests offer?

12. What is meant by educational age? Educational quotient?

13. Which can be more easily determined, the reliability or the validity of a test? Why?

14. What does a reliability coefficient of .85 mean to you? .90? .95?

1. What can you say [illegible] 339-352
of distribution of human traits – to heredity a
2. are diff. due primarily
3. Effect of training upon indiv. diff.

Wednesday

# CHAPTER X

## INDIVIDUAL DIFFERENCES

**The existence of individual differences.**—Although little reference has been made to the fact in the preceding chapters, everyone knows that people differ from one another in virtually every observable trait. If a so-called "homogeneous group" is formed by selecting persons who are alike, or nearly so, in some characteristic, such as age or grade placement in school, the members of the group will vary widely in other characteristics. Thus a group of ten-year-old children, chosen at random, will differ enormously in height, weight, strength of grip, speed in running, intelligence, grade reached in school, ability to read, knowledge of geography, interest in music, politeness, or in practically any other respect in which they may be compared. Although the existence of individual differences is apparent, it will be helpful to note the extent of the differences revealed by certain measurements, and the nature of their distribution among the members of typical groups.

**Variation in height among male college students.**[1]—Table II shows the distribution according to height of men entering the University of Illinois, September, 1927.

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[1] The data for heights and weights of college students were supplied by Dr. J. H. Beard, of the Health Service Station, University of Illinois. They were obtained in the physical examination given to all new students entering the University of Illinois in September, 1927.

A glance at the tabulation reveals that there were few students who were only sixty inches or sixty-one inches in height, and that the number of cases tends to increase up to a height of sixty-eight inches, after which it decreases, ending with a relatively small group who were seventy-five inches in height. In other words, most of the students were of medium height, the number who were extremely short or extremely tall being relatively small.[1]

TABLE II. DISTRIBUTION ACCORDING TO HEIGHT OF MEN ENTERING COLLEGE.

| HEIGHT IN INCHES | NUMBER OF CASES |
|---|---|
| 75 | 18 |
| 74 | 46 |
| 73 | 69 |
| 72 | 163 |
| 71 | 264 |
| 70 | 380 |
| 69 | 432 |
| 68 | 458 |
| 67 | 287 |
| 66 | 301 |
| 65 | 173 |
| 64 | 74 |
| 63 | 40 |
| 62 | 30 |
| 61 | 9 |
| 60 | 8 |
|  | Total 2,752 |

The data of Table II are represented by means of a graph in Figure 24. In this figure the height is denoted by a succession of equal distances marked off from left to right on the base line, and the number of students of each height is represented by the height of the rectangle above the number of inches. Another common form of graphical representation is shown in Figure 25. In constructing this graph, instead of drawing the rectangles as in Figure 24, the mid-points of the tops of the rectangles are located, and these points are then joined by a smooth curve. The curve thus obtained is called a smooth frequency curve.

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[1] A few cases at each extreme of the distribution have been neglected. Measurements were taken to the nearest inch.

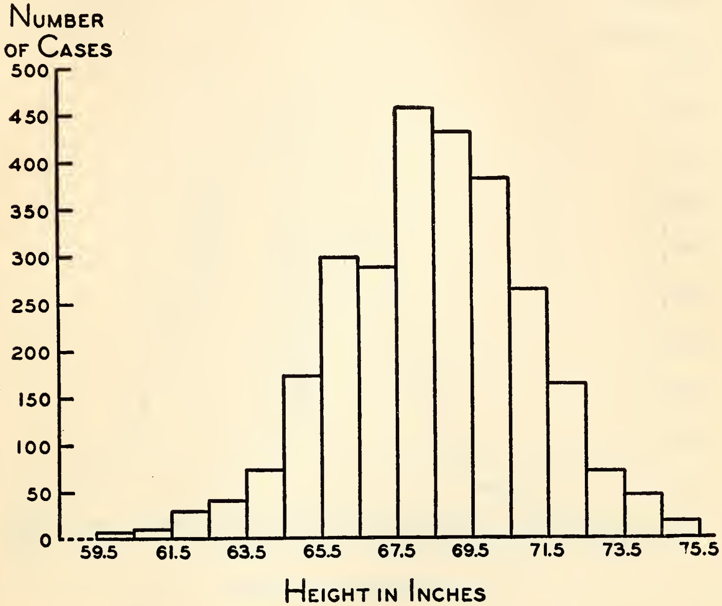

Figure 24. Heights of 2,752 Men Students in the University of Illinois, Column Diagram.

An examination of Table II or of Figure 24 or 25 reveals that there were more students sixty-eight inches in height than of any other height. In any distribution the measure having the greatest frequency is called the *mode.* A more common measure of the central tendency of a distribution, however, is the *median.* The median is the point on the scale on either side of which exactly one-half the measures lie. As indicated in Figure 25, the median height of the students was 68.5 inches. In other words, one-half of the students were more, and one-half were less, than 68.5 inches in height.

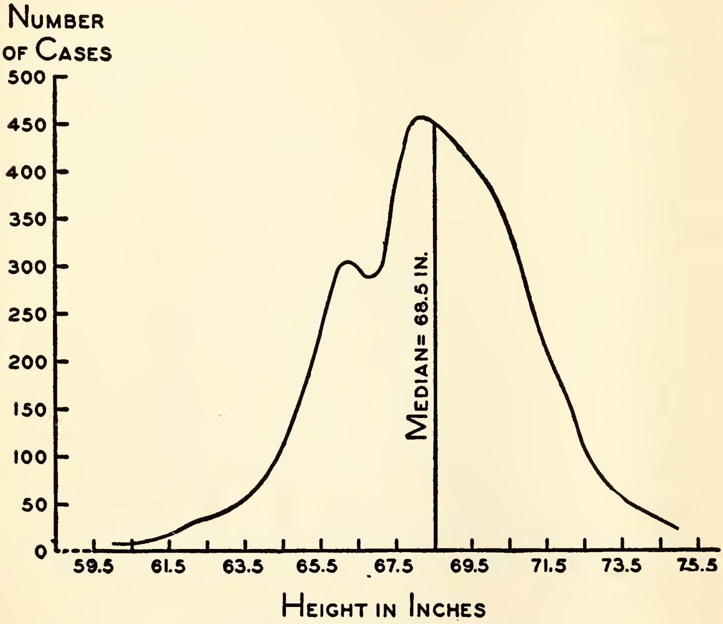

FIGURE 25. HEIGHTS OF 2,752 MEN STUDENTS IN THE UNIVERSITY OF ILLINOIS, SMOOTH FREQUENCY CURVE.

**Variation in weight among male college students.**— As a second illustration of individual differences in physical traits, the weights of 2,721[1] male students in the University of Illinois are given in Table III.

TABLE III. DISTRIBUTION ACCORDING TO WEIGHT OF MEN ENTERING COLLEGE.

| WEIGHT IN POUNDS | NUMBER OF CASES |
|---|---|
| 190–199 | 29 |
| 180–189 | 38 |
| 170–179 | 99 |
| 160–169 | 200 |
| 150–159 | 425 |
| 140–149 | 607 |
| 130–139 | 597 |
| 120–129 | 480 |
| 110–119 | 204 |
| 100–109 | 42 |
|  | Total 2,721 |

The facts of Table III are presented graphically in Figure 26, one type of graph being superimposed on the other. It will be observed that the weights range approximately from 100 pounds to 199 pounds, the mode being the 140–149 interval, and the median 140.6 pounds. Again most of the cases lie near the middle of the distribution, with relatively few cases at the extremes.

**The normal frequency curve.**—The symmetrical, bell-shaped curve illustrated in Figure 27 is called the normal frequency curve. It is highest at the center, and any two points, such as A and A[1], on either side of the center and at equal distances from it, are at equal heights above the base line. This curve has become known as the normal frequency curve from the fact that the distribution of most biological traits within unselected groups is found to be *approximately* in conformity with this curve.[1] This means that if we measure a biological trait, such as height or strength of grip, of a large number of unselected children, such as all twelve-year-olds in a large city school system, the shape of the frequency distribution will approach

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[1] This is essentially the same group as the one for which the heights were given in Table II. As before, a few extreme cases are not included in the distribution in Table III.

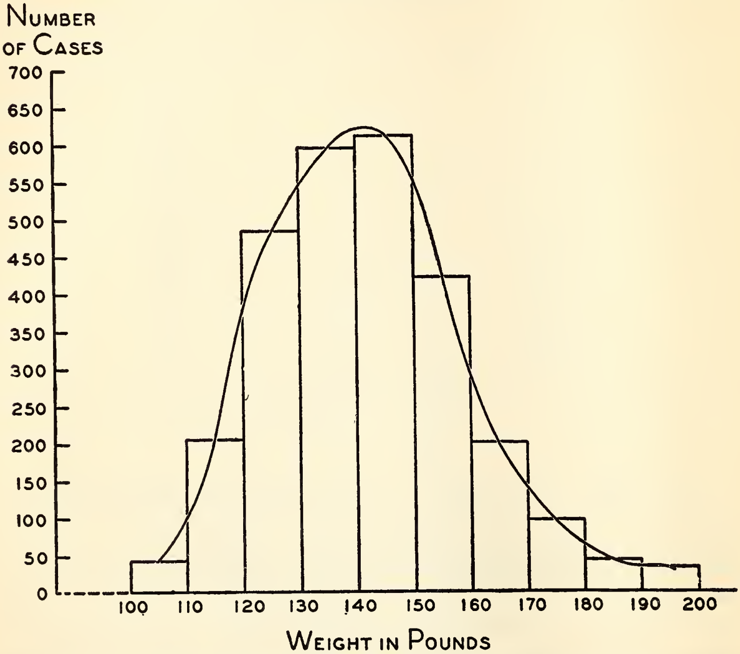

Figure 26. Weights of 2,721 Men Students in the University of Illinois.

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[1] The reader should remember that the word "approximately" is used in this statement. It is not certain that, if accurate measures of a given trait were obtained for an unselected group of persons, the resulting distribution would conform in all details with the normal frequency curve.

that of the curve in Figure 27. In other words, more individuals will be found to possess an average amount of the trait than any other amount; and for the number of persons possessing any given excess above the average amount, there will be an equal number of persons who possess an equal deficiency below the average amount.

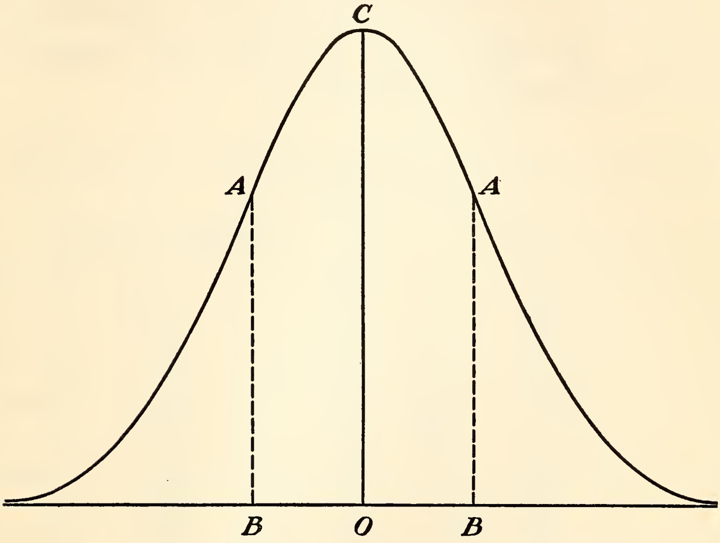

FIGURE 27. THE NORMAL FREQUENCY CURVE.

When a distribution curve departs from the normal curve, it is said to be *skewed.* The skewness of a distribution may be due to lack of precision in the measurements, or to the fact that the cases chosen for measurement do not fairly represent the entire population.

In Figures 25 and 26, the distributions of height and weight among one group of men college students roughly conform to the normal distribution. The departure from a normal distribution is probably due mainly to the fact that the number of cases is not large enough. Students entering college constitute a selected group and this condition probably is a factor.

**Variation in intelligence among high-school seniors.**[1]—During the autumn of 1923 the Otis Self-Administering Test of Mental Ability, Higher Examination, Form A, was given to 11,321 high-school seniors in Illinois high schools. The distribution of the I.Q.'s thus obtained is shown in Table IV and Figure 28.

TABLE IV. THE INTELLIGENCE QUOTIENTS OF 11,321 HIGH-SCHOOL SENIORS.

| I. Q. | NUMBER OF CASES |
|---|---|
| 131 | 32 |
| 126 | 186 |
| 121 | 411 |
| 116 | 821 |
| 111 | 1,313 |
| 106 | 1,786 |
| 101 | 2,110 |
| 96 | 1,921 |
| 91 | 1,382 |
| 86 | 767 |
| 81 | 357 |
| 76 | 153 |
| 71 | 51 |
| 66 | 24 |
| 61 | 7 |
| Median = 103.4 | Total 11,321 |

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[1] The data concerning the intelligence of high-school seniors are taken from ODELL, C. W.—"Are College Students a Select Group?" *University of Illinois Bulletin*, Vol. 24, No. 36, Bureau of Educational Research Bulletin No. 34. Urbana: University of Illinois, 1927, pp. 19, 21.

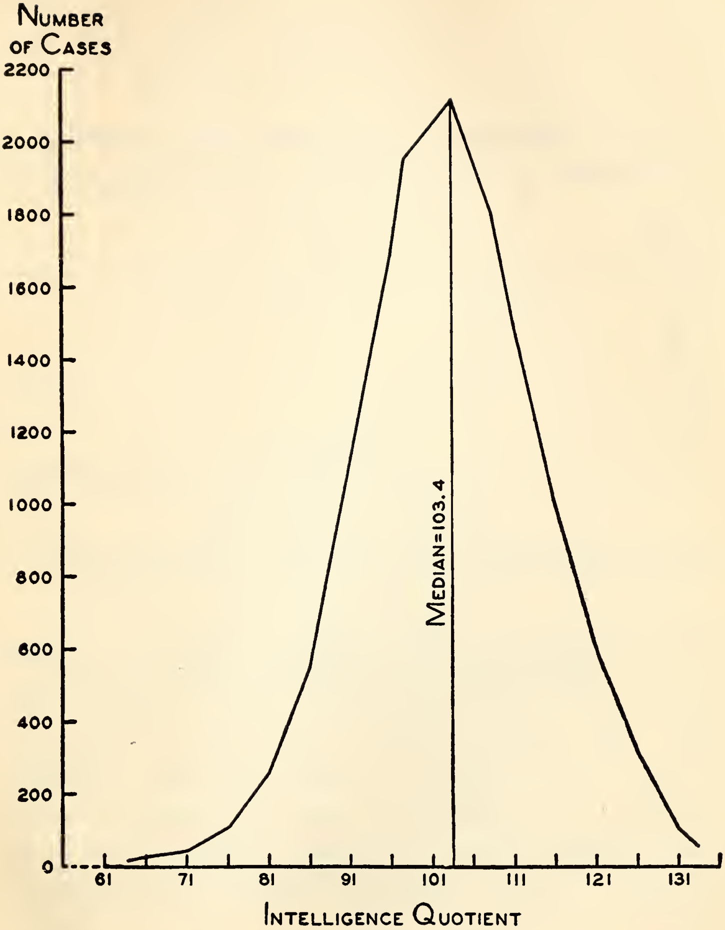

Figure 28. Intelligence Quotients of 11,321 High-School Seniors. (After Odell.)

Although high-school seniors constitute a somewhat selected group,[1] the distribution of intelligence among them approximates the normal distribution. Most of the I.Q.'s are fairly close to 100, there being relatively few cases below 86 or above 121.

**Typical distributions of a grade group according to achievement.**—A few typical distributions of a grade group according to achievement are shown in Figures 29–32.[2] Although these distributions bear some resemblance to the normal distribution, there is distinct skewness. This condition is due, at least in part, to defects in the tests. For example, the abnormal shape of the distribution of the eighth-grade group according to rate of silent reading in Figure 32 is due to imperfections in the test used. However, after allowing for imperfections in

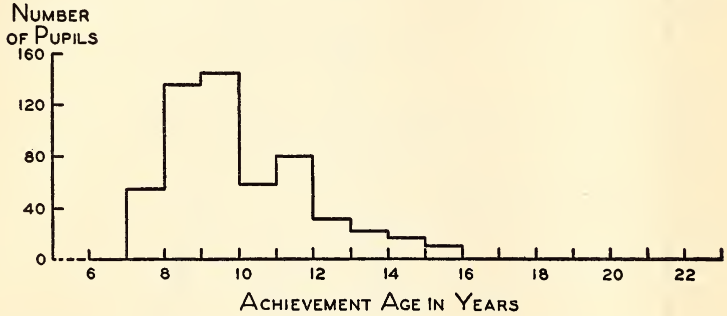

Figure 29. Distribution of Fifth-Grade Pupils According to Achievement Age in Comprehension of Silent Reading.

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[1] A selected group is one that is not representative of the total population. High-school seniors constitute a select group with respect to intelligence, because the majority of those who leave school have I.Q.'s less than 100.

[2] These figures are taken from Monroe, Walter S.—"The Illinois Examination," *University of Illinois Bulletin*, Vol. 19, No. 9, Bureau of Educational Research Bulletin No. 6. Urbana: University of Illinois, 1921. 70 pp.

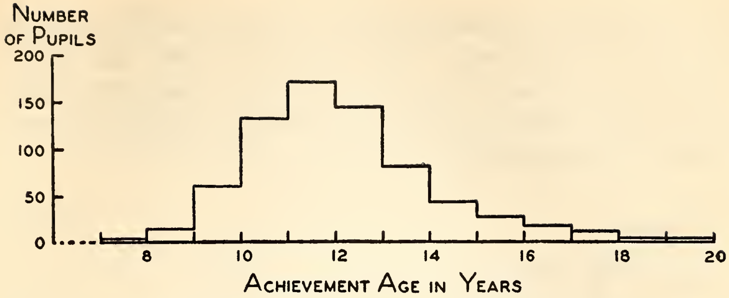

Figure 30. Distribution of Sixth-Grade Pupils According to Achievement Age in Arithmetic.

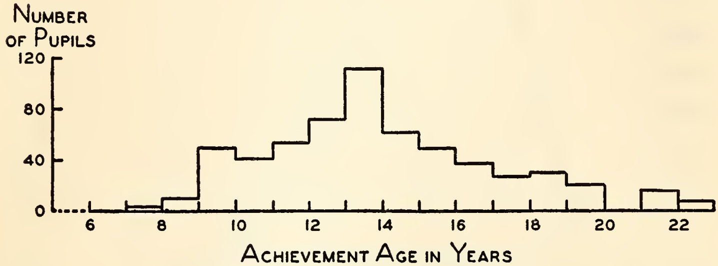

Figure 31. Distribution of Eighth-Grade Pupils According to Achievement Age in Comprehension of Silent Reading.

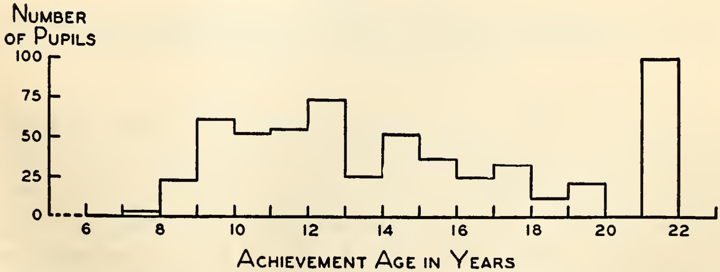

Figure 32. Distribution of Eighth-Grade Pupils According to Achievement Age in Rate of Silent Reading.

the tests that produce skewness and also for the variable errors of measurement, which tend to increase the spread of the distribution, it is clear that there are large individual differences in these grade groups—which include only the children from one city.

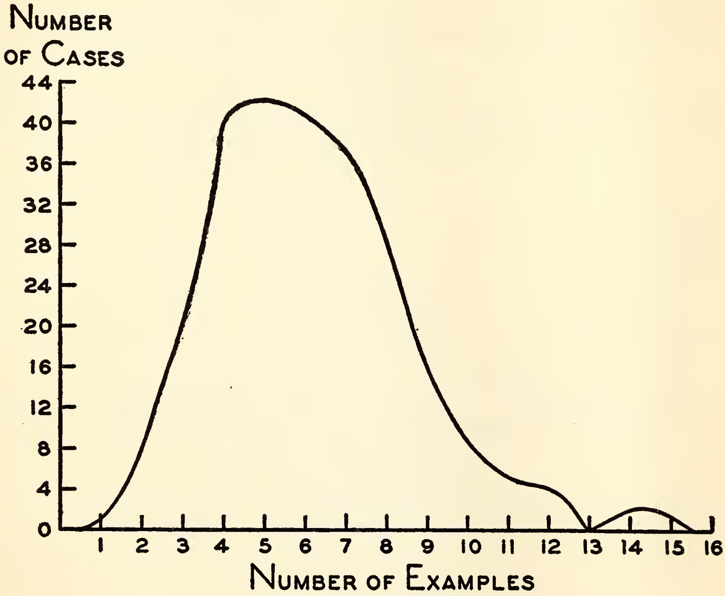

Figure 33. Distribution of 252 College Juniors and Seniors According to Ability to Add Two-Place Numbers.

One further illustration of individual differences is given in Figure 33. In this case the trait measured was a relatively narrow ability, namely, that of adding seven two-place numbers. The test was given to 252 college juniors and seniors, who were asked to do as many examples as they could in two minutes. The curve of Figure 33 shows the distribution of the scores.

**The overlapping of the distributions of grade groups.**— Figure 34[1] shows the distributions according to mental age, as determined by the Illinois General Intelligence Scale, of pupils in Grades IV, VI, and VIII. Each grade group includes several thousand cases. The distributions closely approximate the normal distribution. The extent to which the three curves overlap is interesting and significant. Mental age ranges in Grade IV from five to fifteen and one-half years, with the median at 9.4 years; in Grade

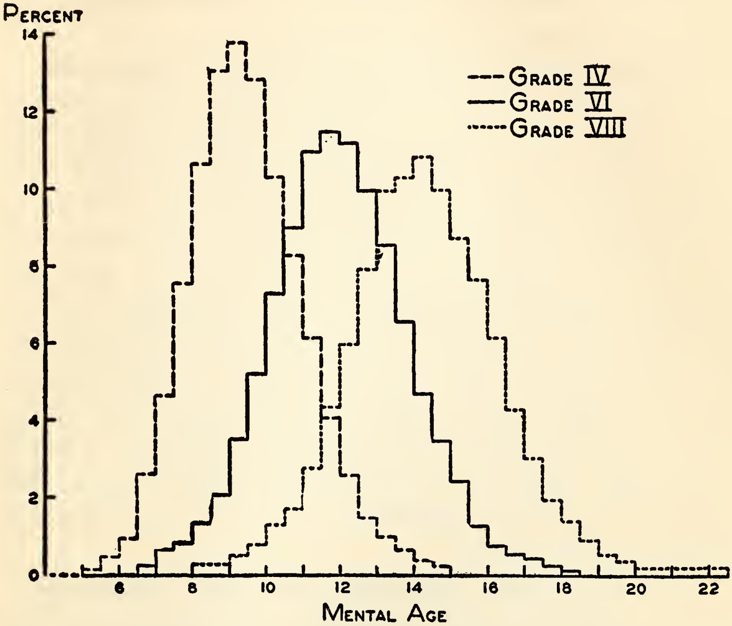

Figure 34. Overlapping of Distributions of Grade Groups According to Mental Age.

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[1] Figure 34 is taken from Monroe, Walter S.—"The Illinois Examination," *University of Illinois Bulletin*, Vol. 19, No. 9, Bureau of Educational Research Bulletin No. 6. Urbana: University of Illinois, 1921. 70 pp.

VI, from six and one-half to eighteen and one-half years, with a median of 12.0 years; and in Grade VIII, from eight to twenty-two and one-half years, the median being 14.3 years. Thus, there are some pupils in Grade IV whose mental ages exceed the median for Grade VIII, and some in Grade VIII whose mental ages are below the median for Grade IV.[1]

**General character of the distribution of human traits.**— The discussion of individual differences up to this point in the chapter may be summarized in a few general statements that are of profound significance to education. In grade groups a wide range of differences will be found to exist in the case of most human traits. Furthermore, if the group is large, every degree of the trait, from the smallest amount possessed by any individual to the greatest amount found in any other, will be represented. In other words, there are no gaps in the distribution. Human beings cannot, therefore, be thought of as falling into a limited number of homogeneous groups. Finally, most traits appear to be distributed according to the theoretical normal probability curve, also called the normal frequency curve.

**Further questions concerning individual differences.**— The recognition of the existence of marked differences among people at once suggests numerous interesting and significant questions, among which the following may be mentioned as of especial importance to education:

Are these differences primarily due to heredity or to environment and training?

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[1] Variable errors of measurement operate to increase the variability of a distribution. It is likely, therefore, that the ranges of the distributions of Figure 34 would be diminished if all variable errors of measurement were eliminated. There can be no doubt, however, that there would still be a large amount of overlapping in the distributions.

What is the effect of training upon individual differences?

To what extent are desirable traits correlated in an individual?

Are there significant innate sex differences?

To what extent are individual differences due to racial ancestry?

A consideration of these questions, together with a few remarks concerning the bearing of the whole matter of individual differences on educational theory and practice, will occupy us during the remainder of the chapter. We shall first consider the question as to whether individual differences are due more largely to nature or to nurture.

**Nature versus nurture as the primary cause of individual differences.**—The relative effect of nature and nurture upon intelligence was considered in Chapter VIII,[1] but the question to be considered here is somewhat different. In Chapter VIII we were concerned with the controversy between the hereditarians and the environmentalists. The former maintain that a child's intelligence is "relatively unaffected by school training or other environmental factors." The latter support the opposite belief. Here we are concerned with the causes of individual differences in intelligence and other traits. Are they native or largely native? Or are they primarily the effects of nurture?

What an individual is at any moment is the resultant of two factors: (1) the original nature of the living cell produced by the union of the ovum of the female parent and the sperm cell of the male, and (2) all the influences external to the cell which have played upon it during its life history up to the moment in question.[1] It is evident that neither nature nor nurture alone can be wholly responsible for any characteristic which a person may possess. Always the two must interact. Without a sufficiently favorable environment life itself could not exist; and any potentiality present in the fertilized ovum at the beginning of life will never appear unless it be developed through the influence of an appropriate environment. But, on the other hand, no environmental force can evoke something which is not latent in the original nature of the individual. Thus, nature may set limits beyond which the individual's development can never proceed, but it is the part of nurture to determine to what extent these limits are reached.

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[1] See pages 255f.

It appears, then, that the question as to whether nature or nurture plays the greater part in determining the status of an individual is, in one sense, a meaningless question. One may as well inquire whether carbon or oxygen plays the greater part in the process of combustion. But it is entirely legitimate to ask whether the differences between individuals are to be explained primarily on the basis of differences in their original natures or differences in their environment and training.

**The inheritance of physical traits.**—Family resemblances in physical traits are a matter of common observation. Children of the same family usually bear greater likenesses to one another than do unrelated children. They tend in some degree to resemble their parents, grandparents, uncles, aunts, and cousins. Furthermore, resemblances exist in the case of traits that could not be influenced by environment—such as color of eyes, shape of head, color of hair, and the like. Any greater similarity in such traits among members of a family than among unrelated persons must be ascribed to the influence of heredity. Pearson[1] has computed the correlation between brothers, between sisters, and between brothers and sisters in such traits as height, eye color, hair color, and cephalic index (ratio of width of head to length of head) and found it to be in each case approximately .50.[2] A coefficient of correlation of approximately 1.00 would indicate that persons having a common heredity are alike in the physical traits considered. A coefficient of approximately 0.00 would indicate no tendency for persons having a common heredity to resemble each other.[3] Consequently a coefficient of .50 should be interpreted to mean that persons having a common heredity do exhibit a marked tendency to resemble each other.[4] If we assume that other physical characteristics are subject to the influence of heredity in the same degree as those measured by Pearson, we must conclude that heredity operates powerfully to determine one's physical traits, and hence is a potent cause of individual differences in these traits.

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[1] The former we shall call "nature," the latter "nurture."

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[1] PEARSON, KARL.—"On the Laws of Inheritance in Man. II. On the Inheritance of Mental and Moral Characters in Man," *Biometrika*, 3:131–90, 1904.

[2] This correlation is far from perfect, the explanation being found in the fact that there is some variation in the germ cells of parents. For example, the germ cells of a tall father do not all carry the determiners that result in tall offspring. On the contrary, the germ cells vary with respect to the character of tallness, their central tendency likely being above the average of those of all fathers, though some of them may fall below this average. Hence a tall father may have a son of average, or even below-average, height. This son, in turn, may have offspring who are above the average in height and who thus resemble their grandfather rather than their father. Thus it will be seen that the influence of heredity should by no means be regarded as reaching back only to the immediate parents.

[3] This does not mean that there might not be resemblances in some cases. Such cases would, however, be offset by others in which there were no resemblances.

[4] See footnote on page 281.

**The inheritance of mental traits.**—When we inquire to what extent heredity determines mental traits, we raise a question that is far more difficult to answer conclusively than is the question of inheritance of physical traits. It is unsafe to argue, by analogy, that mental traits are inherited in the same manner and degree as are physical traits. Unlike color of eyes or cephalic index, there are no mental traits that are obviously unaffected by environment and training. While it may be assumed that mental life is dependent upon the nervous system, and that the latter is subject to the same influences of heredity as are other parts of the physical mechanism, it is also true that the nervous system can be modified enormously by experience.

A crucial test of the relative importance of nature and nurture could conceivably be made in either of two ways. According to one plan, a large number of pairs of brothers, or of sisters, or of brothers and sisters, would be taken as subjects. One of each pair would be placed, immediately after birth, in a certain kind of environment, and be subjected thereafter to a certain type of training, while the other would be placed, also immediately after birth, in a wholly different kind of environment and subjected thereafter to a wholly different type of training. Then after a sufficient length of time the members of each pair would be measured with respect to various mental traits, and tendencies toward likenesses or differences would be observed in each pair of subjects. If the degree of resemblance in each pair approximated that shown by brothers and sisters reared together, we would conclude that nature outweighs nurture. On the other hand, if the degree of resemblance was distinctly less, we would conclude that nurture is the more potent factor.

A second plan of experiment would consist in selecting a large number of unrelated children and placing them, immediately after birth, in similar environments and giving them similar training. Then if, after a sufficient time, the children were found to resemble each other in approximately the same degree as related children, it would be concluded that nurture outweighs nature.

Children, however, cannot be experimented with in this way; hence we must seek whatever other evidence we can find to throw light on our question. Evidence bearing on the question of the relative parts played by nature and by nurture in producing individual differences is afforded by many scores of studies made along various lines. A whole volume would hardly contain an adequate summary and evaluation of these studies. We can do no more here than refer briefly to various lines of investigation that have been followed, and to a few of the more important studies that have been made.

**Studies of family histories.**—Several genealogical studies, each involving the history of some exceptional family through several generations, have been made in order to determine to what extent certain pronounced traits were present throughout a number of successive generations of the family. We shall mention briefly the results obtained in studies of the Kallikak family,[1] the Jukes family,[2] and the Edwards family.[3]

During the Revolutionary War, a feeble-minded woman gave birth to an illegitimate son, who was named after his soldier father, Martin Kallikak. Martin, Jr., became the father of nine children, at least five of whom are said to have been feeble-minded. Six generations of the posterity of Martin, Jr., produced 480 descendants, of whom only forty-six were found to be normal. Of the others, 143 were classified as feeble-minded; the others were unknown. Sexual immorality and drunkenness were prevalent throughout the line. After the war, Martin, Sr., married a normal woman and established another line of descendants, numbering 496. All but five of these were normal, only one being reported as mentally defective, one as a case of religious mania, one as sexually immoral, and two as alcoholics.

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[1] Goddard, H. H.—*The Kallikak Family.* New York: The Macmillan Company, 1912. 121 pp.

[2] Dugdale, R. L.—*The Jukes: A Study in Crime, Pauperism, Disease, and Heredity.* New York: G. P. Putnam's Sons, 1877. 120 pp.

[3] Winship, A. E.—*Jukes-Edwards: A Study in Education and Heredity.* Harrisburg: R. L. Meyers and Company, 1900. 88 pp.

The notorious Jukes family is characterized by pauperism and crime rather than by feeble-mindedness. Max Juke, born in 1720, is described as a shiftless truant who married an equally worthless woman. By 1877 there were approximately 1,200 descendants of this couple. Only twenty of this number had ever learned a trade and ten of these learned it in prison. The history of the family as a whole is replete with thievery, murder, prostitution, pauperism, and debauchery.

In striking contrast with the Kallikaks and the Jukes is the Jonathan Edwards family of approximately 1,400 descendants. Of these, 120 graduated from Yale alone, fourteen were college presidents, more than 100 were professors, and many were authors of distinction.

The conclusion is often reached from the study of such family histories that heredity is the controlling factor in human life. The hereditarian accepts, as the explanation of these cases of family likenesses, the view that native endowment largely decides the issue as to whether the individual will be feeble-minded or intellectually competent, a pauper or a capitalist, a degenerate profligate or a worthy citizen. The environmentalist, however, interprets the matter otherwise. He insists that the difference between the Jukes and the members of the Edwards family was due chiefly to the environment in which the young were reared and the training which they received. It is somewhat more difficult, however, for the environmentalist to account for the prevalence of feeble-mindedness among the Kallikaks. He can rightly point out that many of the persons counted as feeble-minded were so classified merely on the basis of doubtful report and not as the result of a proper examination. Hence there is a possibility of considerable exaggeration. Furthermore, he may contend that, even though feeble-mindedness resulting from gross defects in the nervous system may be inherited, it does not follow that strict limitations with respect to organization and function are in like manner imposed upon normal nervous systems.

**Studies of eminent men.**—Several investigations have been made to determine to what extent eminent men and ordinary men differ in the number of their relatives who attain distinction. The studies of Galton[1] and of Woods[2] will serve as illustrations. Galton selected for study 977 men, each of whom had attained a degree of eminence which Galton estimated to be reached by only one man in four thousand chosen at random. He then inquired into the number of relatives of equal eminence each of the 977 possessed. He found that the 977 men had 535 equally eminent relatives as closely related to them as grandfather or grandson, whereas 977 men selected at random would have only four such relatives. He concluded that men who are endowed with high abilities easily overcome the obstacles imposed by inferiority of social rank, but that men who are aided by social advantages do not attain eminence unless they possess a high order of natural ability.

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[1] GALTON, F.—*Hereditary Genius.* London: Macmillan and Company, 1869. 379 pp.

[2] WOODS, F. A.—*Mental and Moral Heredity in Royalty.* New York: Henry Holt and Company, 1906. 312 pp.

Woods studied 671 members of European royal families, the historical range of the cases extending over several centuries. Each individual was rated for mentality and for morality on a scale ranging from one to ten. The ratings were assigned by Woods on the basis of the statements of biographers and historians. He obtained the following correlations as measures of family resemblance:

| | |
|---|---|
| In mental ability— | |
| Father and offspring, | .31 |
| Grandfather and offspring, | .16 |
| Greatgrandfather and offspring, | .15 |
| In morals— | |
| Father and offspring, | .30 |
| Grandfather and offspring, | .175 |

Woods regarded it as a very significant fact that family resemblance was as great on the maternal side as on the paternal, since maternal grandfathers represented different courts from the paternal and hence different environments from those in which the offspring were reared. He also found that the offspring who inherited thrones did not become illustrious more often than other children of the family upon whom the succession did not devolve. Therefore, this important environmental circumstance had no material influence in determining the level of distinction reached by the individual.

As in the case of the family histories mentioned in the preceding section, the facts presented by Galton and by Woods are explained differently by the hereditarian and the environmentalist.

**Thorndike's study of twins.**—We shall mention only one of several studies that have been made to ascertain the extent to which twins show greater similarity than do siblings.[1] Thorndike[2] gave six tests to fifty pairs of twins ranging in age from nine years to fourteen years. The correlations obtained were approximately twice as high as in the case of siblings. They were as follows:

| | |
|---|---|
| (1) A-test | .69 |
| (2) a-t and r-e tests | .71 |
| (3) Misspelled words | .80 |
| (4) Addition | .75 |
| (5) Multiplication | .84 |
| (6) Opposites | .90 |

Thorndike interpreted these data as showing that differences in heredity are far more significant than are such differences in environment and training as were operative in the case of public-school pupils of New York City at the beginning of the twentieth century. His argument runs thus: If the resemblances are due to environment and training, then (1) older twins, up to the age of leaving home, should become more alike than the younger twins; (2) siblings not more than four or five years apart in age should show nearly as great resemblance as twins; and (3) twins should show greater resemblances in traits that are much subject to training than in traits in which little training has been given. The facts are, however, (1) that the twins who were from twelve to fourteen years old were less alike than those who were from nine to eleven years of age; (2) the twins were more than twice as much alike as siblings are; and (3) while the twins showed greater resemblance in the two traits most subject to training (addition and multiplication) than in the two least subject to training (the A-test and the a-t and r-e tests), they showed less resemblance in the former than in the two which are moderately subject to training (misspelled words and opposites).

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[1] Siblings are children of the same parents, but not twins.

[2] Thorndike, E. L.—"Measurements of Twins," *Archives of Philosophy, Psychology and Scientific Methods*, 1:1–64, September, 1905.

**Studies of foster children.**—Two outstanding investigations in connection with the nature-nurture question are the study by Freeman[1] and others at Chicago, and the study by Burks[2] at Stanford. The subjects in the Chicago study included seventy-four children who had been given a mental test several years previous, when they were placed in foster homes—where they remained until the same test was repeated at the time of this study. There were in addition 130 pairs of siblings who had been separated at least four years, during which time each child had been in continuous residence in a foster home. There were also forty pairs of children, each pair consisting of an own child and a foster child in the same home. There were seventy-two pairs of unrelated foster children reared in the same family.

In addition to measurements of intelligence of the children, attention was given to the characteristics of the own and foster parents, the status of the homes in which the children were located, the progress which the foster children made in school, and their general conduct. Among the general conclusions of the investigators, the following may be mentioned:

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[1] FREEMAN, F. N., and others.—"The Influence of Environment on the Intelligence, School Achievement, and Conduct of Foster Children," *The Twenty-Seventh Yearbook of the National Society for the Study of Education*, Part I. Bloomington: The Public School Publishing Company, 1928, Chapter IX.

[2] BURKS, B. S.—"The Relative Influence of Nature and Nurture upon Mental Development; A Comparative Study of Foster Parent-Foster Child Resemblance and True Parent-True Child Resemblance," *The Twenty-Seventh Yearbook of the National Society for the Study of Education*, Part I. Bloomington: The Public School Publishing Company, 1928, Chapter X.

1. The foster children showed a substantial gain in intelligence after placement in foster homes, the greatest gains being made by the children in the better homes and also by the children who were placed at the earliest ages.

2. The correlation of the intelligence of siblings reared in different homes was much lower than is found between siblings reared together.

3. Unrelated children reared in the same home resembled each other in intelligence to an extent of a correlation of .25 to .37.

4. Mental deficiencies in the own parents of the foster children were reflected to some extent in the foster children, but to a much smaller degree than would have been the case if environment had not played any part in determining intelligence. While many of the own parents of the foster children were morally defective, there were relatively few cases of serious misbehavior among the children.

In the Stanford investigation there were two groups of subjects: (1) a foster group of 204 children and their foster parents, and (2) a control group of 105 children and their own parents. The second group was chosen so as to be closely comparable with the first. The children in the foster group had been placed in their foster homes before the age of twelve months and were between the ages of five and fourteen years at the time of the investigation. The children's I.Q.'s were determined by the application of the Stanford-Binet Test and were correlated, in the case of each group, with the following hereditary and environmental factors: father's mental age, mother's mental age, father's vocabulary, mother's vocabulary, the status of the home as determined by the Whittier Home Scale, the cultural level of the home as measured by the culture scale prepared by the investigators, and the income of the parents. The correlations, corrected for attenuation,[1] were:

| | Child's I.Q. and | Foster | Control |
|---|---|---|---|
| (1) | Father's M. A. | .09 | .55 |
| (2) | Mother's M. A. | .23 | .57 |
| (3) | Father's Vocabulary | .14 | .52 |
| (4) | Mother's Vocabulary | .25 | .48 |
| (5) | Whittier Index | .24 | .48 |
| (6) | Culture Index | .29 | .49 |
| (7) | Income | .26 | 26 |

Burks concluded that home environment is responsible for about 17 per cent of the variance in intelligence, parental intelligence for about 33 per cent of the variance, and the total contribution of heredity for perhaps 75 or 80 per cent. She also states that 70 per cent of school children have I.Q.'s within six to nine points of that represented by their innate intelligence, and that the best home environment can elevate, or the poorest environment can depress, the I.Q. as much as twenty points.

**Conclusions concerning the relative effect of nature and nurture upon individual differences in mental traits.**—The evidence presented in the preceding pages indicates that both nature and nurture contribute to the individual differences in mental traits. People differ, in part because their original natures are different, and in part because of differences in environment and training.

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[1] Correcting a coefficient of correlation for attenuation means to correct for the effect of variable errors in the measures of the traits concerned.

The total evidence is perhaps usually interpreted by educational psychologists as indicating the preponderance of nature over nurture, but there appear to be some grounds for questioning this view. A few psychologists, notably Watson, maintain that environment is the determining factor and that given a healthy, well-formed infant it is possible by means of suitable environment and training to produce any type of person desired.[1] If this contention should be true, it would be theoretically possible to produce a generation of children who would not exhibit individual differences, and it would be practically possible to reduce greatly individual differences by providing nursery schools and other means for controlling the environment of young children more fully than they are now controlled. It should be noted, however, that if Watson should be right, it may not be desirable to eliminate, or even to reduce greatly, individual differences. It may be more desirable to increase individual differences, especially at the upper levels. "It is not so important to make all men equal as to make them all better; and a good deal could be said in favor of the thesis that, if time allowed for making only a few better, these few might well be the ones who already promise to be the best."[2]

**The effects of equal practice on individual differences in achievement.**—Given a typical class, will equal practice of a function such as doing addition examples of a particular type tend to increase or decrease the magnitude of the individual differences in the performance of this function? This question may also be expressed as follows: If the members of a typical class are given equal practice on a given function, will those who are best at the beginning of the practice gain more or less than those who are poorest? The experimental procedure for answering this question is suggested by the second form of statement. For example, Donovan and Thorndike[1] practiced twenty-nine fourth-grade boys two minutes twice daily for thirty periods in adding columns of ten digits each. The score was the number of examples correct, and the gross increase in score was taken as the gain. In interpreting the data obtained the subjects were divided into seven groups on the basis of initial scores, and the average gross gain of each group was computed. The results were as follows:

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[1] Watson, J. B.—*Behaviorism.* New York: Peoples' Institute Publishing Company, 1925, p. 82.

[2] Woodworth, R. S.—"The Nursery School and Child Development," *School and Society*, 29:504, April 20, 1929.

| GROUP | INITIAL SCORES | AVERAGE INITIAL SCORE | AVERAGE GAIN |
|---|---|---|---|
| I | 4, 4, 5, 6 | 4.8 | 5.3 |
| II | 7, 7, 8, 8 | 7.5 | 10.0 |
| III | 9, 9, 9, 9 | 9 | 5.3 |
| IV | 10, 10, 11, 11, 12, 12, 12 | 11.1 | 6.6 |
| V | 13, 13, 13 | 13 | 8.3 |
| VI | 14, 14, 15, 16, 16 | 15 | 6.8 |
| VII | 19, 21 | 20 | 11.0 |

Examination of the average gains of the different groups reveals that there is a tendency for those who were best at the beginning of the series of practices to make the greatest improvement. This tendency is perhaps more clearly shown by two other measures of the effects of the training. The "rank" correlation between initial scores and gross gains is +.23. The average gross gains of the upper and lower halves of the entire group are 9.4 and 8.6, respectively. Hence it appears that, in this experiment, practice in addition of one-place numbers slightly increased the individual differences in the group.

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[1] DONOVAN, M. E., and THORNDIKE, E. L.—"Improvement in a Practice Experiment under School Conditions," *American Journal of Psychology*, 24: 426–28, July, 1913.

The problem of determining the effect of equal practice on individual differences, however, is not to be solved in this simple fashion. Some investigators have concluded that those pupils who were best at the beginning of the practices made the least improvement. Gates,[1] for example, who carried on a more elaborate investigation than Donovan and Thorndike, interpreted her data as indicating that equal practice decreases individual differences. It is not appropriate to consider here the reasons for this lack of agreement, but some comment on the difficulties encountered by an investigator will assist the reader in understanding this problem and in realizing that the foundational research of educational psychology is not so simple as it may appear from a casual consideration of the questions to be studied.

**Difficulties encountered in studying the effects of equal practice on individual differences in achievement.**—A prerequisite for studying the effects of equal practice on individual differences is a definition of "equal practice." It was pointed out in connection with the consideration of learning curves[2] that just what constitutes equal amounts of practice is not known. We may speak of practice for equal amounts of time, or of practice involving equal numbers of units of work done, but in neither case is it known that the amounts of practice are equal. Furthermore, practice for equal lengths of time probably will not affect individual differences in precisely the same way as practice involving the same number of units of work. Hence, whichever way an investigator defines equal amounts of practice, his conclusions are not beyond question.

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[1] Gates, Georgina.—"Individual Differences as Affected by Practice," *Archives of Psychology*, No. 58, August, 1922. 74 pp.

[2] See Chapter V, page 167, footnote.

In order to determine the effects of practice, it is necessary to measure each learner's ability in the function practiced at the beginning and at the close of the period of training. The likelihood of the presence of relatively large errors in such measures, at least in the scores of some of the learners, was emphasized in the preceding chapter.[1] It follows that a given increase in score from the initial to the final testing cannot safely be regarded as an accurate measure of the improvement made. Educational tests are subject to two other important limitations: they do not have true zero points, and their scales are not composed of equal units. As a result of the first limitation, a score of eight does not mean twice as much ability as a score of four. Also, in consequence of the second limitation, an increase in score from five to ten may represent an amount of gain that is distinctly different from the gain represented by an increase in score from ten to fifteen.

Even if it were possible to secure satisfactory measures of ability at the beginning and at the close of practice, two very difficult questions remain to be answered: (1) How shall the gain of each learner be expressed? (2) How shall the gains made by the different learners be compared in order to determine who has made the greater gain?[1] The first of these two questions may be resolved into two further questions: (a) Shall ability, and hence improvement, be measured in terms of work done in a given time or in terms of the time required to do a given amount of work? (b) Shall absolute or relative gains be considered? That each of these questions presents a real dilemma may be seen by considering the following case.

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[1] See especially page 321.

Suppose we wish to compare the improvement in arithmetic made by pupils A and B during a given period of training. Suppose, further, that a ten-minute test is given at the beginning of the training and again at the close, the scores for A being 5 and 10 examples, respectively, and for B, 2 and 5 examples, respectively. Which made the greater gain? Since A gained 5 examples and B only 3 examples, it may be argued that the former made the greater gain. If the gains are expressed as per cents of the initial scores, however, it appears that B made more improvement than A, since the former gained 3/2, or 150 per cent, while the latter gained only 5/5, or 100 per cent. Hence A made the greater *absolute* gain, but B the greater *relative* gain.

If we express the scores and gains in time units, however, we find that B made the larger absolute gain. A required 2 minutes per example on the initial test and 1 minute per example on the final test. His gain, therefore, was 1 minute per example. B required 5 minutes and 2 minutes per example on the first and last tests, respectively, and hence gained 3 minutes per example; that is, he reduced his time score per example three times as much as did A.

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[1] Lack of space prevents an adequate treatment of these two questions here. The reader who is interested in a further discussion of them should consult Whitley, Mary T.—"An Empirical Study of Certain Tests for Individual Differences," *Archives of Psychology*, No. 19, August, 1911. 146 pp.

It appears, then, that one's conclusions as to the effects of practice on individual differences may be very different according as one measures improvement absolutely or relatively, and in work units or in time units. Since it appears to be as permissible to define ability in terms of the time required to do a given amount of work[1] as to define it in terms of the amount of work done in a given time, both measures of improvement should be employed in studying the problem of the effects of practice on individual differences. As to the relative merits of absolute and relative gains, it may be said that the former are preferable when gains are expressed in work units; and the latter, when gains are in time units.[2]

Numerous methods of comparing individual gains have been employed. Among them, the following appear to be the soundest and most serviceable, though none of them is entirely adequate and free from objection. Hence, it is desirable that all of them be employed in a given study and the results obtained from all taken into consideration in arriving at conclusions as to whether practice increased or diminished the initial differences in the function in question.

1. Taking the scores at the beginning of practice, one may pair off the pupil with the highest score with the pupil having the lowest score, the pupil having the next highest score with the one having the next lowest, and so on. Ratios may then be calculated from these pairs of scores by dividing the larger by the smaller. A second set of

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[1] This assumes that the task is one in which the rate of performance is a significant aspect, or dimension, of ability. See page 311.

[2] Space cannot be taken here for a justification of this statement.

ratios may be calculated from the scores of the same pairs of pupils at the end of practice. If these ratios tend to increase, it would appear that practice increased initial differences; if they tend to decrease, the differences are diminished.

2. One may compare the average gain, both gross and relative, of one portion of the group of learners with the average gain of another portion—for example, the initially highest fourth with the initially lowest fourth.

3. The initial scores and gains may be correlated to determine whether the initially high or the initially low made the greater gains. If the coefficient of correlation is positive, it indicates that practice made the group more unlike; if it is negative, that practice made the learners more alike.

4. The coefficient of variability[1] may be computed for the group at the beginning and at the end of practice. As it increases or decreases, so will the initial differences among the members of the group.

It frequently happens that in a given case these various measures of the effects of practice on individual differences do not point to the same conclusion. Some of them may indicate that practice increased initial differences; and others, that these differences were reduced by the training. In such a case, one can hardly be certain what the effects of the practice really were.

**General summary of experimental evidence relative to the effects of practice on individual differences.**—One of the present writers has summarized, in an unpublished study,[1] the experimental evidence set forth in twenty-seven investigations[2] in which the problem of the effects of practice on initial differences among learners was considered. Included with these in the summary were four other studies containing data that could be interpreted with reference to the problem, although the original investigators had not so interpreted them. In many of these thirty-one studies the raw scores were reported. In all such cases other measures of the effects of the practice than those upon which the original investigator had based his conclusions were computed. A brief general summary of the conclusions which the present writer reached from these thirty-one studies follows:

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[1] This is obtained by dividing some measure of variability of the group by some measure of the average—for example, the standard deviation may be divided by the mean, or the quartile deviation may be divided by the median. The latter is more convenient, though somewhat less accurate. The quotient is multiplied by 100 to remove the decimal point.

If each investigation is considered as a whole, in four of them the initially best gained most; in sixteen the initially poorest tended to catch up during practice; and in eleven the effects of the training on initial differences were slight or uncertain. If each function is considered separately and counted as many times as training was given in it, by different investigators or by the same investigator with different groups, the result is: In eight cases practice increased the initial differences; in thirty-nine cases practice decreased the initial differences; and in thirty-six cases the effects of the training on initial differences were slight or uncertain.[3]

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[1] Reagan, G. W.—"The Effects of Practice on Individual Differences," A Doctor's Thesis, University of Illinois Library, 1928. For another summary consult Peterson, Joseph, and Barlow, M. C.—"The Effects of Practice on Individual Differences," *The Twenty-Seventh Yearbook of the National Society for the Study of Education*, Part II. Bloomington, Illinois: The Public School Publishing Company, 1928, Chapter XIV.

[2] The studies by Donovan and Thorndike and by Gates, mentioned above, were among this number.

[3] The reader will note that when the present writer treated the raw scores in other ways than those employed by the original investigators he did not always

**General conclusions concerning the effect of practice on individual differences in achievement.**—Many of the most eminent educational psychologists have supported the view that equal amounts of training operate to increase individual differences in achievement.[1] The evidence just summarized indicates that training sometimes increases individual differences in achievement, but more often, it seems, it reduces these differences.[2] It is doubtless true that initial ability is an important factor in determining improvability; but there are also other potent factors. In the words of Hollingworth, "We have, above all, failed to make sufficient allowance for the overwhelming importance of incentive, motive, attitude, and purpose, and the large rôle these play in determining the possible achievements of a nervous system."[3] Hence, if other factors are not controlled, we should not expect the effect

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arrive at the same conclusion as they had reached. In fact, the majority of the original investigators concluded that the practice had increased the initial differences among their subjects. If their conclusions are summarized in terms of the various functions practiced, the results are: In the case of forty-four functions training increased the differences; with twenty-two functions the opposite was true; and in eight cases the effects of the training on initial differences were uncertain.

[1] For statements of this view, see:

THORNDIKE, E. L.—*Educational Psychology*, Vol. III. New York: Bureau of Publications, Teachers College, Columbia University, 1914, pp. 304–05.

STARCH, DANIEL.—*Educational Psychology*, New York: The Macmillan Company, 1919, p. 88, 91.

HENMON, V. A. C.—"Improvement in School Subjects Throughout the School Year," *Journal of Educational Research*, 1:81–95, February, 1920.

[2] This conclusion is in agreement with the results obtained in three experiments by Reagan. See REAGAN, G. W.—"The Effects of Practice on Individual Differences." A Doctor's Thesis, University of Illinois Library, 1928. In the first experiment three functions were considered: word checking, arranging sentences, and multiplication. The second included only word checking and the third, cancellation, classification, and arithmetic.

[3] HOLLINGWORTH, H. L.—"Correlation of Abilities as Affected by Practice," *Journal of Educational Psychology*, 4:412, September, 1913.

of practice on individual differences to be always the same. In order to determine the effect of practice with precision it would be necessary to control all other factors affecting improvement in the function being studied.

**Correlation of abilities.**—We turn now to the question: To what extent are desirable traits correlated in an individual? Is there a tendency for superiority in one respect to be accompanied by superiority in other respects? Or is there some law of compensation by virtue of which the individual who is above average in some trait must pay the price of inferiority in some other trait? Popular opinion has generally subscribed to the latter view. It has been thought that intellectual capacity of high order is likely to be accompanied by general physical inefficiency, that bright children tend to be below average in bodily health and vigor, that a superior capacity for academic achievement is attended by a lack of practical judgment and an incapacity for dealing with the affairs of everyday life, that the scientist is likely to have no taste or capacity for music and poetry, and so on. We shall consider briefly what support a few representative measurements of human abilities lend to this view of human nature.

Simpson[1] tested twelve different abilities (listed in the first column of Table V) in two groups of subjects differing widely in intelligence and found these traits correlated to the extent shown in the table. The numbers at the tops of the columns correspond with the traits as numbered in the first column. Decimal points have been omitted from the coefficients of correlation. The large size of a number of the coefficients[1] and the absence of negative coefficients indicate a marked tendency for the individuals who were superior in one trait to be superior in the others also.

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[1] Simpson, B. R.—"Correlations of Mental Abilities," *Teachers College, Columbia University Contributions to Education*, No. 53. New York: Bureau of Publications, Columbia University, 1912. 122 pp.

TABLE V. CORRELATIONS AMONG CERTAIN ABILITIES. (After Simpson)

| Tests | Correlations between Tests | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 1. Ebbinghaus test | | | | | | | | | | | |
| 2. Hard opposites | 92 | | | | | | | | | | |
| 3. Memory of words | 92 | 92 | | | | | | | | | |
| 4. Easy opposites | 75 | 81 | 68 | | | | | | | | |
| 5. A-test | 68 | 76 | 70 | 71 | | | | | | | |
| 6. Memory of passages | 91 | 86 | 89 | 69 | 60 | | | | | | |
| 7. Adding | 71 | 74 | 56 | 70 | 67 | 66 | | | | | |
| 8. Geometrical forms | 54 | 64 | 67 | 54 | 94 | 60 | 44 | | | | |
| 9 Learning pairs | 72 | 72 | 82 | 43 | 44 | 63 | 46 | 40 | | | |
| 10. Completing words | 50 | 70 | 51 | 50 | 84 | 38 | 77 | 61 | 34 | | |
| 11. Drawing lines | 26 | 25 | 06 | 53 | 27 | 12 | 27 | 30 | 04 | 17 | |
| 12. Estimating lengths | 52 | 55 | 59 | 56 | 57 | 58 | 17 | 35 | 54 | 22 | 55 |

Starch[2] computed the correlations among the marks received in various school studies by pupils in Grades V to VIII and found them to be as reported in Table VI. Most of the coefficients are large and none are negative. There is a marked tendency for the pupil who is good, average, or poor in one subject to be good, average, or poor in all other subjects.

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[1] These coefficients have not been corrected for attenuation. Hence it is likely that several of them have been materially reduced by the presence of variable errors in the measures of the traits.

[2] STARCH, DANIEL.—"Correlations among Abilities in School Studies," *Journal of Educational Psychology*, 4:415–18, September, 1913.

Table VI. Correlations among Grades in School Studies. (After Starch)

| Studies | Correlation |
|---|---|
| Arithmetic and language | .85 |
| “ “ geography | .83 |
| “ “ history | .73 |
| “ “ reading | .67 |
| “ “ spelling | .55 |
| Language and geography | .85 |
| “ “ history | .77 |
| “ “ reading | .83 |
| “ “ spelling | .71 |
| Geography and history | .81 |
| “ “ reading | .80 |
| “ “ spelling | .52 |
| History and reading | .67 |
| “ “ spelling | .37 |
| Reading and spelling | .58 |

It well may happen that an individual will stand relatively high in some type of performance in which his training has been approximately equivalent to the training of the other members of the group with whom he is compared, but at the same time he may occupy a relatively low position in the group with respect to some other performance in which he has had much less training than the other members of the group. To determine the general character of the intercorrelations among capacities, therefore, it is necessary that the subjects have had approximately equal opportunities to develop the various capacities that are measured. The change in intercorrelations among functions as the result of practice in those functions is well shown by Hollingworth's study.[1] Hollingworth gave his subjects 205 practices in a number of functions and computed the average correlation of each function with all the others at various stages of the practice. The results are shown in Table VII. It will be seen that on the first trial the correlations were low, two of them being negative, but that they increased throughout the period of training, becoming significant and positive at the close of the practice.

TABLE VII. EFFECTS OF PRACTICE ON CORRELATIONS AMONG ABILITIES. (After Hollingworth)

| TRIAL | AVERAGE CORRELATION OF EACH TEST WITH ALL THE OTHER TESTS | | | | | | |
|---|---|---|---|---|---|---|---|
| | ADDING | OPPOSITES | COLOR NAMING | DISCRIMINATION | COÖRDINATION | TAPPING | AVERAGE |
| 1 | .19 | .10 | .15 | —.07 | —.15 | .17 | .065 |
| 5 | .41 | .26 | .15 | .35 | .21 | .32 | .280 |
| 25 | .50 | .35 | .43 | .27 | .03 | .35 | .320 |
| 80 | .55 | .43 | .53 | .31 | .18 | .34 | .390 |
| 205 | .48 | .62 | .61 | .35 | .34 | .52 | .490 |

We shall not burden the reader with further evidence indicating that, on the whole, there is a positive correlation among various capacities. The few studies cited would not afford conclusive evidence of this fact were they not of the same general tenor as numerous others that could be presented. Thorndike sums up the evidence on the question by saying, "It is very, very hard to find any case of a negative correlation between desirable mental functions."[1] This statement does not mean, of course, that an individual may not possess a high degree of aptitude for some type of performance and yet be mediocre, or even below the average, in many other traits. One may be a genius in the field of music, for example, but of inferior capacity in drawing or in mathematics. But when it is applied to people generally, the statement that desirable traits are positively correlated doubtless holds.

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[1] HOLLINGWORTH, H. L.—"Correlation of Abilities as Affected by Practice," *Journal of Educational Psychology*, 4:405–14, September, 1913.

**Variations in the development of gifted children.**—Terman's studies of a group of gifted children[2] have provided us with detailed and dependable information concerning their development. The data collected in this elaborate investigation[3] are not in agreement with the popular belief that a genius is "queer" in other respects. "There is no shred of evidence to support the widespread opinion that typically the precocious child is weak, undersized, or nervously unstable."[4] On the contrary the gifted child tends to be somewhat superior physically. In regard to achievements in school subjects it is shown that the degree of evenness for gifted children is not conspicuously different from that for unselected children. "Gifted children are unique individuals, but unselected children are no less so. Gifted children may be more successful specialists and thus attract more attention, but it should be observed that they are superior in all abilities. On the other hand, children of ordinary or mediocre general intelligence often possess specialized abilities that are overlooked because they are not so conspicuous as when they appear in the gifted specialist."[1]

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[1] Thorndike, E. L.—*Educational Psychology*, Vol. III. New York: Teachers College, Columbia University, 1914, p. 362.

[2] These were children having I.Q.'s of 140 and above.

[3] Terman, L. M., and others.—*Genetic Studies of Genius*, Vol. I. Stanford University: Stanford University Press, 1925. 648 pp.

[4] *Ibid.*, p. 634.

**Sex differences.**—Aside from the differences due to the part played by each sex in the economy of biological reproduction, there are other easily observable differences between the sexes. Girls mature earlier than boys and excel them in height and weight between the ages of twelve and fifteen years approximately. After maturity, however, the males excel in height, weight, lung capacity, muscular strength, and the like. As a result of their physical superiority, perhaps, men have, throughout the ages, dominated the weaker sex and have played a more imposing part in the affairs of the world. It is not strange that their intellectual supremacy has pretty generally been taken for granted—at least by them.

Popular psychology has tended toward a rather sharp distinction between the intellectual qualities of the sexes. Doubtless the differences between the occupations followed and the responsibilities assumed by the sexes have been reflected in differences in interests, in information possessed, in skills exhibited, and so on. But the existence of such differences as these does not necessarily imply that there are innate differences in intellectual capacity.

We shall not summarize here the evidence bearing on the question of possible differences between the sexes in native mental capacities. The evidence is not of such character and amount as to enable us to reach definite conclusions as to the precise nature and extent of the differences that may exist. One conclusion, however, seems certain, namely, that there is no great amount of difference in the innate mental capacities of the sexes. The differences that have been found are relatively small, and most of them may well have been due to differences in training or to such factors as errors in measurement and the limited number of cases.

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[1] De Voss, J. C.—"Specialization of the Abilities of Gifted Children," *Genetic Studies of Genius*, Vol. I. Stanford University: Stanford University Press, 1925, p. 339.

As an explanation of the fact that most of the outstanding figures in every line of endeavor have been men, Thorndike[1] has advanced the hypothesis that there is a slightly greater variability among men than among women. As a consequence, a relatively small number of men are superior to all women, and at the same time a relatively small number are inferior to all women, the average of the two groups being essentially the same. Hence, not only most of the world's greatest geniuses, but also the worst criminals and the most idiotic idiots, have been men. Thorndike's hypothesis, however, has not been generally accepted.[2]

**Difficulties in determining racial and national differences in intelligence.**—The measurement of differences in intelligence among individuals is always complicated by the fact that intelligence can be measured only through achievement,[3] which is in some measure dependent upon environmental factors that may be markedly different in the case of these individuals. This disturbing effect of significant variations in environmental influences is especially pronounced when the attempt is made to compare various races and nationalities on the basis of intelligence. The problem is also further complicated by the fact that it is very difficult to avoid unfair selection in comparing racial or national groups. If, for example, comparisons are made between white and colored high-school students, it is very likely that the latter are more highly selected than the former. Or again, if foreign immigrants in the United States are compared with native-born Americans, there is ground for question whether the immigrants are fairly representative of the national groups from which they came.

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[1] Thorndike, E. L.—*Educational Psychology*, Vol. III. New York: Teachers College, Columbia University, 1914, pp. 185–96.

[2] For example, see Terman, L. M.—*The Measurement of Intelligence*. Boston: Houghton Mifflin Company, 1916, pp. 68–72. See also Terman, L. M., and others.—*Genetic Studies of Genius*, Vol. I. Stanford University: Stanford University Press, 1925, p. 634. In this reference Terman appears to subscribe to Thorndike's hypothesis.

[3] See pages 264-65.

**Comparison of negroes and whites in intelligence.**—The psychological testing carried on in the United States Army during the World War[1] affords valuable data concerning the relative intelligence of adult members of the white and the negro races. The Army Alpha intelligence test was given to a large number of men from all the states and the scores translated into seven letter grades as follows: A, B, C+, C, C—, D, and D—. The grade of A represented the score obtained by approximately the highest five per cent, and D— the score made by approximately the lowest seven per cent, of all the cases of literate men. A different test was administered to illiterates.

We may compare the letter grades obtained by a group of 93,973 enlisted white men with the letter grades of a group of 18,891 enlisted negroes, both groups being so chosen as to be fairly representative of the enlisted men of both races in the country at large. The results, expressed in the per cent of each group making each letter grade, are as follows:[1]

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[1] For a report of this testing, see Yerkes, R. M.—*Psychological Examining in the United States Army. Memoirs of the National Academy of Sciences*, Vol. XV. Washington: Government Printing Office, 1921. 890 pp.

| LETTER GRADE | PER CENT OF GROUP MAKING EACH GRADE | |
|---|---|---|
| | Whites | Negroes |
| A | 4.1 | .01 |
| B | 8.0 | .06 |
| C+ | 15.0 | 2.0 |
| C | 25.0 | 5.7 |
| C— | 23.8 | 12.9 |
| D | 17.1 | 29.7 |
| D— | 7.0 | 49.0 |

It will be seen that the per cent of whites receiving grades of A and B was about seventeen times as large as in the case of negroes, and that the per cent of the latter receiving D and D— grades was more than three times as large as in the case of the former. The grade of A was forty-one times as frequent among the whites as among the negroes, and the grade of D— was seven times as frequent among the negroes as among the whites.[2] It thus appears that the whites are greatly superior to the negroes in intelligence. The above figures, however, do not tell the whole story. When the grades obtained by a group of 4,705 negroes from the five northern states of Illinois, Indiana, New Jersey, New York, and Pennsylvania are compared with the grades of 6,486 negroes from the four southern states of Alabama, Georgia, Louisiana, and Mississippi, the results are:[3]

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[1] YERKES, *op. cit.*, p. 707.

[2] Since the frequencies are expressed as per cents of the whole number of cases, the larger number of whites does not affect the comparisons.

[3] YERKES, *op. cit.*, p. 734.

| LETTER GRADES | PER CENT OF GROUP RECEIVING EACH GRADE | |
|---|---|---|
| | Northern Negro | Southern Negro |
| A | 0.7 | 0.1 |
| B | 2.7 | 0.2 |
| C+ | 7.2 | 0.7 |
| C | 18.0 | 3.4 |
| C— | 25.8 | 9.6 |
| D | 31.2 | 29.2 |
| D— | 14.4 | 57.0 |

We thus find that the northern negroes are markedly superior to those in the southern states. Two possible explanations of this difference may be offered. On the one hand, it may be contended that, on the whole, the negroes who migrate to the north are natively superior to those who remain in the south. On the other hand, the differences may be due to the more favorable educational and other environmental conditions enjoyed by the northern negroes rather than to any native superiority. There is possibly some measure of truth in both hypotheses, but the second seems likely to be the more influential factor in accounting for the differences. If the superiority of the northern negroes is chiefly due to superior advantages of environment and training, then the same explanation may, at least in part, account for the wide differences between the whites and the negroes. It is probable that the white race excels the negroes in native intellectual capacity, but the exact amount of difference cannot be stated at present.

**The intelligence of other races.**—Studies of the intelligence of the American Indian agree in showing that the

Indian is inferior even to the negro. Hunter[1] found, from a study of more than 700 cases, that the pure-blood Indian is inferior in intelligence to the Indian having white blood in his veins, and furthermore that the Indian having the greater amount of white blood is superior to the one with the lesser amount. The median scores on the Otis Intelligence Test made by groups of different degrees of mixture of white and Indian blood were reported to be approximately as follows: one-fourth Indian blood, 109; one-half Indian blood, 91; three-fourths Indian blood, 78; full Indian blood, 67. The median score for 1,366 fifteen-year-old children is reported by Otis as being about 123. This evidence thus indicates that the Indian is very inferior to the white man in intelligence. This conviction is strengthened by the fact that the Indians studied by Hunter were students at the Haskell Institute and were thus a selected group.

Pyle[2] reports that Chinese children in the United States stand fairly high in the following tests: (1) rote memory, (2) logical memory, (3) substitution, (4) analogies, and (5) spot pattern. He states that the scores made by the Chinese children are much nearer the norm for American white city children than are those made by negroes and by rural white children. He believes that, if proper allowance is made for language differences, the mentality of the Chinese children would equal that of white children.

**Scores on Army Alpha made by various immigrant groups.**—In the course of the army testing, 12,407 white immigrants from fifteen European countries and from

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[1] Hunter, W. S., and Sommermeier, Eloise.—"The Relation of Degree of Indian Blood to Score on the Otis Intelligence Test," *Journal of Comparative Psychology*, 2:257–77, June, 1922.

[2] Pyle, W. H.—"A Study of the Mental and Physical Characteristics of the Chinese," *School and Society*, 8:264–69, August 31, 1918.

Canada were included. The scores obtained by them on various tests have been expressed by Brigham[1] in terms of a combined scale and found to be as follows:

TABLE VIII. COMBINED SCORES OBTAINED BY VARIOUS IMMIGRANT GROUPS IN THE UNITED STATES ARMY. (After Brigham)

| | | | |
|---|---|---|---|
| England | 14.87 | Belgium | 12.79 |
| Scotland | 14.34 | Ireland | 12.32 |
| Holland | 14.32 | Austria | 12.27 |
| Germany | 13.88 | Turkey | 12.02 |
| Denmark | 13.69 | Greece | 11.90 |
| Canada | 13.66 | Russia | 11.34 |
| Sweden | 13.30 | Italy | 11.01 |
| Norway | 12.98 | Poland | 10.74 |

The differences set forth in Table VIII have been interpreted as indicating that these national groups differ significantly in native mentality. This interpretation becomes doubtful, however, when we consider the relationship found between length of residence in the United States and the scores obtained by the immigrants. Brigham[2] grouped the immigrants on basis of length of residence in this country and found the average scores varying as follows:

| YEARS OF RESIDENCE | AVERAGE SCORE |
|---|---|
| 0– 5 | 11.41 |
| 6–10 | 11.74 |
| 11–15 | 12.47 |
| 16–20 | 13.55 |
| Over 20 | 13.82 |

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[1] BRIGHAM, C. C.—*A Study of American Intelligence.* Princeton: Princeton University Press, 1923, pp. 120–21.

[2] *Ibid.*, p. 89.

The increase in scores with longer residence in this country would appear to be due either to a gradual deterioration in the immigrant stock in each successive later period or to an improvement in intelligence due to longer periods of subjection to the influence of American education and other environmental factors. The latter explanation seems likely to be the truer one. It is obviously opposed to the hypothesis of Nordic supremacy among the people of the white race, a hypothesis which has been urged by some writers and vigorously denied by others.[1]

**Résumé.**—The most important conclusions reached in the discussion thus far may be briefly set down at this point. The members of an unselected group differ widely in every respect that is of any great moment to education. The distributions of the various traits generally tend to conform to the normal frequency distribution. That is to say, most persons possess only a moderate amount of any given ability, with relatively few persons having either a very small or a very large amount of that ability. These differences are in part due to nature and in part to the result of dissimilarities in environment and training, but the relative influence of these factors has not yet been accurately measured. It appears, furthermore, that desirable traits are correlated in individuals, so that there is a tendency for the person who is superior, average, or inferior in one respect to be superior, average, or inferior respectively in all respects. There seem to be but little, if any, significant differences in the innate capacities of the two sexes. There appears to be some measure of difference between the native mentalities of the various

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[1] For example, cf. BRIGHAM, *op. cit.*, and BAGLEY, W. C.—*Determinism in Education.* Baltimore: Warwick and York, Inc., 1925. Chapter VI.

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races, though the extent of these differences is uncertain. Certainly there is a great amount of overlapping on the part of any two racial or national groups, and hence some persons in any such group will excel a portion of any other such group.

It should not be overlooked that, while the emphasis has been placed on differences in intelligence—since this is probably the trait of most consequence in education—there are also many other differences that education must take into account. There are, to mention some of the more important ones, differences in physical health and vigor, in physiological maturity, in social maturity, in contact with the world through travel, in the range and character of reading, in the use of language, in interests, in probable future careers, in the degree of mastery of school subjects previously pursued, in amounts and character of further training that is likely to be obtained, in vision and purpose, in energy and enthusiasm—indeed, the recital might be extended indefinitely. Truly, no two persons are alike. And it is well that this is true; for it is only these differences that produce individuality and personality.

**The significance of individual differences to education.** —Since children differ vastly in capacity to learn, with respect to both the level of possible attainment and the rate of learning, it is obvious that the instructional procedures best adapted to one child cannot be equally appropriate for all other children. The subject matter suitable for one learner may be very unsuitable for another. The manner of presentation that is most effective in the case of some pupils may be very ineffective in the case of others. No one rate of progress that will be equally appropriate for all individuals can be fixed. In any lock-step system some will be hurried beyond their powers of comprehension, assimilation, and retention, while others are not kept busily occupied and thus fall into disastrous habits of dawdling and idleness.

A manufacturing establishment—say, an automobile plant—may standardize its materials and processes and turn out a product that is essentially uniform. With education, however, the case is very different. The educator cannot draw up detailed specifications of the product to be turned out by the school and then proceed on a time schedule to bring each child into conformity with these specifications. The school could not turn out a uniform, standardized product if it would, and should not if it could.

In certain respects and within certain limits, the welfare of the social group whose interests the school is to serve demands some degree of homogeneity among the citizens of the social order. For example, it is highly desirable, perhaps very essential to group stability, that all members of the group attain some degree of mastery of the common language, to the end that they may be able to speak, read, and write it sufficiently well for purposes of effective intercommunication. Again, there is a certain body of ideals, characteristic of the group and closely related to its welfare, which every member should entertain and cherish. There is, likewise, a body of information concerning matters of import to the group which all its members should possess. In short, social solidarity is dependent upon some measure of likeness and like-mindedness in the individuals composing the group.

The welfare of the social group, however, is also dependent upon certain differences among its members. There is, for instance, a wide range of group needs and interests to be served by the various vocational activities. The division of labor results in one person's attention to mining, another's to farming, a third's devotion to the practice of medicine, and so on. One vocation demands a large measure of physical strength and vigor, though perhaps only a limited amount of intellectual capacity and training, while another is possible only for the person of a high order of intellectual endowment and a long course of rigorous training. Yet each vocation contributes to the common good. There is a need for the musician's talent, the scientist's interest in his chosen field, the actor's art, the poet's rhyme, the inventor's genius, the blacksmith's brawn, the bricklayer's skill—for every good service of mind or muscle that one may choose to render.

It is, then, the supreme problem of education to adapt the training and instruction of the school to the varying needs, interests, and capacities of the pupil in such a way as to prepare him best to render to the social group the most valuable service within his power. It is not within the scope of our subject to suggest ways and means of coping with this problem.[1] Educational psychology is concerned with the problem only to the extent of demonstrating its existence and significance. It is within the province of the methodologist and the school administrator to find the solution.

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[1] For a discussion of this problem as it applies to secondary education, see MONROE, WALTER S.—*Directing Learning in the High School.* Garden City, New York: Doubleday, Doran and Company, Inc., 1927. Chapter XII.

## LEARNING EXERCISES FOR THE READER

1. What meaning should be attached to the expression "homogeneous group"?

2. In the light of the evidence presented in this chapter, which seems to you to be the more influential factor in producing individual differences, nature or nurture?

3. Assuming that it is possible to do either, should education seek to increase or to reduce individual differences?

4. Why is it that, despite the numerous experimental investigations of the effects of practice on individual differences, no conclusive answer to the question has been obtained?

5. Explain the meaning of the statement that desirable traits are positively correlated. Does this statement mean that, if John is above the average of his class in reading, he is also above the average in arithmetic? Why?

6. In Table VII, what five pairs of traits show the highest correlations? What five pairs show the lowest correlations?

7. Why did practice change the two negative correlations in Table X to positive correlations?

8. If there are no significant differences in the intellectual capacities of the sexes, what explanation can be offered for the fact that men have far surpassed women in music, literature, painting, science, invention, and so on?

9. What constitutes one's environment? If twins are reared together, attending the same school, playing the same games, associating with the same children, and the like, are their environments identical?

10. Have you developed any of your capacities to the highest possible level? Is it likely that anyone does so? What, then, is the practical significance of the statement that "nature sets limits beyond which the individual's development can never proceed"?

11. Should such conditions as are portrayed in Figure 34 exist? If not, how could they be prevented?

12. What would be a conservative estimate of the ratio of the ability of the brightest pupil in a typical grade group to that of the slowest pupil in the group?

13. In reading educational literature, one sometimes encoun-

ters the expression, "the mythical average child." Is it appropriate to employ the term "mythical"? Explain.

14. Prepare an argument for or against the hypothesis of Nordic supremacy. See page 386 and the references cited thereon.

15. If the original nature of the human infant has not changed materially during the past 30,000 years, how can you explain the superiority of the adult to-day over the adult of prehistoric times?

Order of development of mental traits?
Influence of adolescence upon rate of development?
Characteristics of diff. age levels?

Wed

# CHAPTER XI

## CHARACTERISTICS OF CHILDREN AT DIFFERENT PEDAGOGICAL LEVELS

**The problem of this chapter.**—There is a vast difference between the human infant and the human adult. A long period of time—approximately one-third of the normal span of life—is required for the transformation of the former into the latter. This transformation may be designated by such terms as growth, development, or maturation. In this chapter we shall first consider the general nature of the process of growth, both physical and mental. It will be necessary, in this connection, to consider two questions that are of considerable importance to educational theory and practice, namely: (1) What relations exist among various mental traits (such as perception, memory, imagination, reasoning) with respect to their order of development in the individual? (2) What influence does the approach or the arrival of adolescence have upon the rate of the individual's development? Having discussed these questions, we shall then attempt to describe, in a general manner, the most important characteristics of learners at various significant pedagogical levels.

**Physical growth.**—Although numerous studies of the physical growth of children have been made, it is impossible as yet to describe accurately and completely the course of physical development from birth to maturity. Most of the data available at present have been obtained by measuring certain aspects of bodily growth—such as height, weight, lung capacity, strength of grip—in the case of children of various ages rather than by repeated measurements of the same children. We are thus in the position of comparing, for example, a group of ten-year-old children with another group of eleven-year-old children

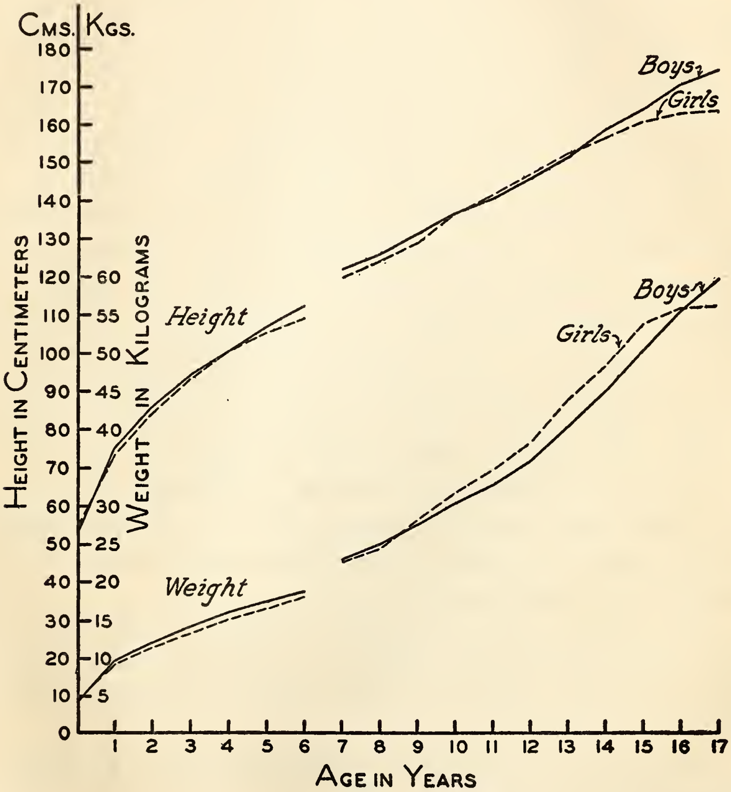

Figure 35. Growth in Height (in Centimeters) and in Weight (in Kilograms). (Curves based upon data from Baldwin.)

without the assurance that the latter represent what the former will become in another year. Furthermore, the amount and rate of growth vary with a number of factors, such as race and nationality, family ancestry, economic and social conditions, school conditions, and the like. Hence, the results obtained by studying one sampling of persons may not hold for another sampling.

Of the many studies of physical growth that have been reported, only two will be drawn upon briefly here for data that will throw some light on the problem of physical growth. The first to be mentioned is the study by Baldwin.[1] The results shown in Table IX and Figure 35 were obtained in two separate investigations. In the first, the height and weight of 36,958 Iowa children—18,770 boys and 18,188 girls—ranging in age from birth to six years are reported. In the second, repeated measurements over a period of years were made of the height and weight of sixty boys and sixty girls of the Horace Mann School in New York City. Of the second group of children Baldwin says that they represent good types of development, and adds, "The norms, which are among the highest in the world, show what school medical inspection, physical training, and directed play can do for children; for many of these boys and girls were sickly or under-nourished when small, and several are Hebrews, who are racially of small stature and small features."[2]

The absolute and percentile increases in Table IX and also the growth curves in Figure 35 are discontinuous from age six to age seven, since the group of children repre-

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[1] Baldwin, B. T.—"The Physical Growth of Children from Birth to Maturity." *University of Iowa Studies in Child Welfare,* Vol. I, No. 1. Iowa City: University of Iowa, 1920. 411 pp.

[2] *Ibid.*, p. 151.

Table IX. Gr

| Age in Year |
|---|
| Height in Centimeters |
| Weight in Kilograms |
| Increase in Height |
| Increase in Weight |
| Percentile Incr in Height |
| Percentile Incr in Weight |

without the assurance that the latter represent what the former will become in another year. Furthermore, the amount and rate of growth vary with a number of factors, such as race and nationality, family ancestry, economic and social conditions, school conditions, and the like. Hence, the results obtained by studying one sampling of persons may not hold for another sampling.

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[1] Baldwin, B. T.—"The Physical Growth of Children from Birth to Maturity." *University of Iowa Studies in Child Welfare*, Vol. I, No. 1. Iowa City: University of Iowa, 1920. 411 pp.

[2] *Ibid.*, p. 151.

TABLE IX. GROWTH IN HEIGHT AND IN WEIGHT, AND ABSOLUTE AND PERCENTILE ANNUAL INCREASES IN HEIGHT AND WEIGHT, FROM BIRTH TO AGE SEVENTEEN YEARS, MALES AND FEMALES. (BASED UPON DATA FROM BALDWIN.)

| AGE IN YEARS | SEX | MEASUREMENTS | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
| Height in Centimeters | M | 52.4 | 74.7 | 85.8 | 93.7 | 99.9 | 106.4 | 112.0 | 121.6 | 125.7 | 130.7 | 135.5 | 140.3 | 144.8 | 151.0 | 157.0 | 163.1 | 169.2 | 172.9 |
| | F | 53.9 | 73.2 | 83.9 | 92.4 | 99.9 | 105.3 | 109.7 | 120.0 | 124.2 | 129.1 | 135.5 | 140.6 | 145.6 | 151.7 | 156.0 | 159.7 | 161.6 | 161.8 |
| Weight in Kilograms | M | 4.0 | 9.5 | 11.9 | 14.0 | 15.9 | 17.2 | 18.6 | 22.9 | 24.7 | 27.5 | 29.9 | 32.7 | 35.5 | 40.1 | 44.5 | 49.9 | 55.0 | 59.1 |
| | F | 4.3 | 9.2 | 11.4 | 13.3 | 15.0 | 16.5 | 18.1 | 22.8 | 24.4 | 27.8 | 31.4 | 34.4 | 38.0 | 43.7 | 48.1 | 43.5 | 55.4 | 55.7 |
| Increase in Height | M | | 22.3 | 11.2 | 7.9 | 6.2 | 6.4 | 5.7 | — | 4.1 | 5.0 | 4.8 | 4.8 | 4.5 | 6.2 | 6.0 | 6.2 | 6.1 | 3.6 |
| | F | | 19.3 | 10.8 | 8.4 | 7.5 | 5.4 | 4.6 | — | 4.1 | 5.0 | 6.4 | 5.1 | 5.0 | 6.1 | 4.3 | 3.7 | 1.8 | 0.2 |
| Increase in Weight | M | | 5.5 | 2.4 | 2.1 | 1.9 | 1.3 | 1.4 | — | 1.8 | 2.8 | 2.4 | 2.7 | 2.9 | 4.5 | 4.5 | 5.4 | 5.1 | 4.2 |
| | F | | 4.9 | 2.2 | 1.9 | 1.7 | 1.5 | 1.6 | — | 1.7 | 3.3 | 3.7 | 3.0 | 3.6 | 5.7 | 4.4 | 5.3 | 2.0 | 0.3 |
| Percentile Increase in Height | M | | 42.6 | 14.9 | 9.2 | 6.6 | 6.4 | 5.3 | — | 3.4 | 3.9 | 3.6 | 3.5 | 3.2 | 4.2 | 3.3 | 3.9 | 3.7 | 2.1 |
| | F | | 35.8 | 14.8 | 10.0 | 8.2 | 5.4 | 4.4 | — | 3.4 | 4.0 | 4.9 | 3.7 | 3.5 | 4.2 | 2.8 | 2.3 | 1.1 | 0.1 |
| Percentile Increase in Weight | M | | 138.5 | 24.9 | 17.3 | 13.2 | 8.4 | 8.1 | — | 7.9 | 11.3 | 8.7 | 9.0 | 8.8 | 12.7 | 11.1 | 12.0 | 10.2 | 7.5 |
| | F | | 115.5 | 24.4 | 16.9 | 12.4 | 10.3 | 9.7 | — | 7.2 | 13.6 | 13.1 | 9.3 | 10.5 | 15.0 | 10.1 | 11.0 | 3.7 | 0.5 |

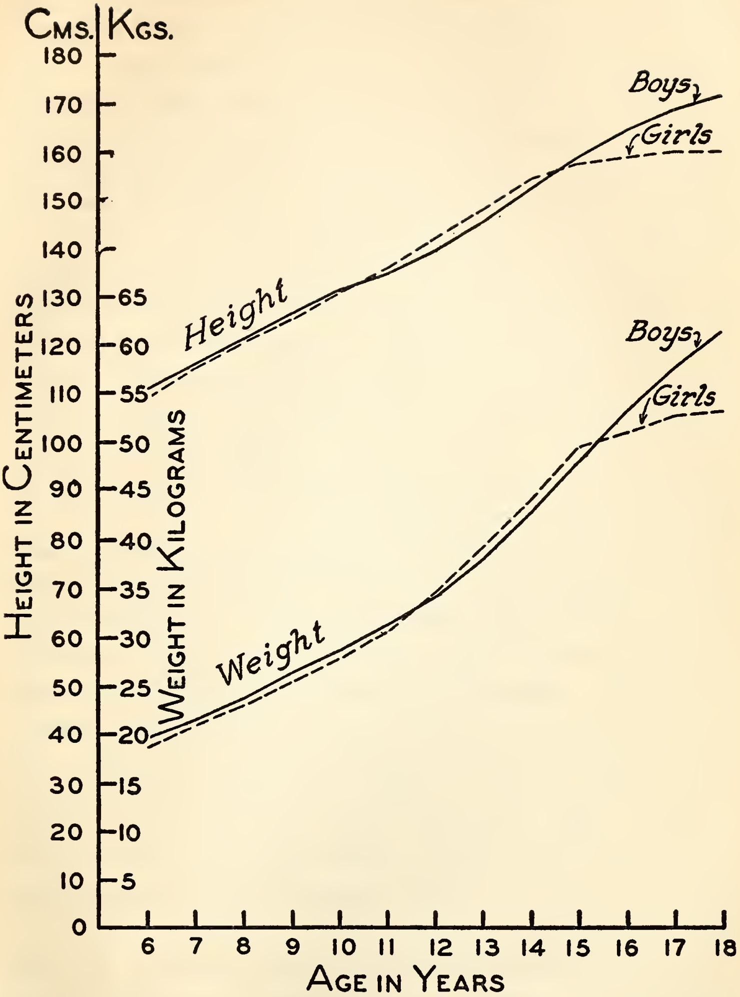

Figure 36. Growth in Height (in Centimeters) and in Weight (in Kilograms). (Curves based upon data from Smedley.)

sented in the measurements up to and including six years of age is not comparable with the group upon which the measurements for age seven and later were made.

Table X and Figure 36 are based upon data obtained by Smedley.[1] The subjects were 6,259 pupils in the Chicago public schools. Various physical measurements were taken, of which only heights and weights are reported in the table and in the corresponding figure.

A comparison of Tables IX and X shows that at every age level represented in both tables Smedley's norms are lower than those of Baldwin. It was pointed out above that the children from whom Baldwin obtained measurements for age seven and later were not a typical group of school children. It is probable, therefore, that Smedley's norms are more nearly representative of city school pupils generally than are Baldwin's.

Baldwin's data indicate that girls surpass boys at birth in both height and weight, but fall below them in both respects by the end of the first year. A rapid decline in rate of growth in height and weight is shown during the early years. Growth in height is fairly constant from the age of four years up to the age of thirteen, after which a rapid decrease in rate of growth is found for girls. The rate for boys does not decline until the age of sixteen is reached. The curves for weight show a general tendency toward increased rate of growth after age seven until the decline in rate sets in at age fifteen for girls and at sixteen for boys.

Smedley's data tell much the same story as do those of Baldwin, though some differences are found. Both show that boys are slightly superior to girls in height and weight during the earlier years and considerably superior after both sexes have reached adolescence. According to Baldwin (Table IX), girls become equal to boys in height at the age of ten and remain slightly superior until the age of fourteen. Smedley's data (Table X) show that the girls surpass the boys in height at age eleven and fall below them again at fifteen. More marked differences are found between the two tables when weights are compared. Table IX shows that girls surpass the boys at age nine and continue in the lead until the age of seventeen is reached, while Table X indicates that the girls do not surpass the boys until the age of twelve and are lighter again at the age of sixteen.

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[1] SMEDLEY, F. W.—"Report of the Committee on Child-Study and Pedagogic Investigation," *Forty-Sixth Annual Report of the Board of Education, Chicago Public Schools.* Chicago: Board of Education, 1901, pp. 37–116.

One interesting feature of growth curves is the relation between the rate of growth and the onset of adolescence. An examination of the tables and figures shows that, after the first few years of life, the rate of growth in height becomes fairly constant. The absolute gains for boys are somewhat larger from twelve[1] to sixteen than for the period preceding, but the percentile gains show little change. Table IX shows a similar increase in the case of girls at the age of nine, though this increase does not appear in Table X until the eleventh year. In the case of weight, the increases in rate of gain are somewhat more pronounced, setting in for boys at about the age of twelve and for girls somewhat earlier. Baldwin says, in speaking of growth in height: "In both the boys' and girls' curves there is a slight adolescent acceleration which appears earlier for the girls than for the boys, with a slight retardation before this pubescent acceleration. . . . In cases where there are periods of retardation during early adolescence, this is usually followed by a period of rapid acceleration during adolescence. If the increment of growth before adolescence is relatively uniform, this uniformity tends to persist throughout adolescence, resulting in some instances in growth curves in height becoming practically a straight line."[1]

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[1] In Table IX, the gain of 6.2 cm. in the column for age thirteen is the gain made between the age of twelve and the age of thirteen.

**Other aspects of physical growth.**—Physical growth is by no means completely described in terms of annual changes in height and weight. Just as these differ from each other in general, so does each differ from the growth of particular organs or parts of the body. Brain growth, for example, proceeds in a manner altogether different from the way in which height or weight changes. The same is true of the heart, the liver, the sex glands, the teeth, the muscles, the lungs—or, in fact, of any other part of the body.

**Difficult to evaluate physical development of particular children.**—In view of the fact that there are individual differences in all these respects, it is obviously an extremely difficult task to describe completely and accurately the manner in which physical growth normally proceeds. Even if such a description were given, it would not apply in all respects to any particular child. Terman says: "—the growth status of the *individual* can never be evaluated by a table of norms computed from growth *averages*. Each individual is a law unto himself."[2] This means that if we had a carefully prepared and elaborate table showing the average weight, height, chest expansion, etc., for the different ages and races and for each sex separately, we could not reliably determine the degree of abnormality of any given child. Some children are naturally small; others are naturally large. A child who is naturally small may be normal even though his measurements are below the average for his sex, age, and race.

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[1] Baldwin, *op. cit.*, p. 73.

[2] Terman, L. M.—*The Hygiene of the School Child.* Boston: Houghton Mifflin Company, 1914, p. 21.

**Mental development inadequately described.**—Mental life is manifested in a large number of different types of performances; or, to state the case differently, general mental ability at any level consists of a multitude of constituent abilities which are in some degree distinct from one another. A complete description of any level of mental development, therefore, would require accurate measurements of many abilities, and a satisfactory account of the course of mental growth would necessitate the repetition of all these measurements at various times in the life of the individual in question. Furthermore, if a general description applicable to people in general is sought, these measurements must be made with a large number of cases, since individual differences prevail in this respect as in all others. Instead of accurate measurements of a vast number of constituent abilities made upon the same individuals at numerous intervals from birth to maturity, we have only inaccurate measures of a relatively small number of abilities, these measures being obtained from persons at different age levels rather than from the same persons at different times. It is obvious, therefore, that much uncertainty must attach to any attempt to describe mental development.

**Opposed theories of the order of development of mental traits.**—Some psychologists have advocated a theory of periodic or serial development of mental traits. According to this theory such traits as observation (perception), memory, imagination, and reasoning appear and become prominent in the child's development at fairly definite ages. This theory includes also the belief that the trait must be exercised and developed when it appears. If this is not done, the trait will atrophy. Thus, early in the elementary school period the child is predominantly an observer but is unable to reason. A little later he is a memorizer and does not become a reasoner until approximately the senior-high-school period.[1]

Opposed to the theory of serial development is the theory of concomitant development.[2] The advocates of the latter view hold that the various mental traits develop concomitantly from infancy to adulthood. They insist, for example, that the child does not spend a number of years merely in observing, followed by another period of years during which observation declines and memory plays the dominant rôle, after which reason begins to function; but rather that the child from the earliest years of life remembers some part of his perceptual experiences and engages in reflective thinking to the extent that his experiences enable him to think. All of the various mental processes, it is held, develop together, and gain strength and support each from the others.

The implications of these theories for education are apparent. If the theory of serial development is accepted, the school training should be widely different in character at different stages. The early years should be devoted to sense training and observational learning. Then a period of memorization should follow, the prevailing method of instruction being drill. Finally, the emphasis should be shifted to subject matter and methods requiring thinking. On the other hand, the theory of concomitant development would require that training at all levels recognize the child's ability to engage in all types of responses, and that no single type of response be over-emphasized at any level to the neglect of other types. In other words, the learner should at all stages be regarded as a perceiving, imagining, remembering, and thinking person, the main question at any moment being, not what type of response is the pupil able to make at this level, but rather what learning exercises has his past experience equipped him to respond to in an effective manner.

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[1] For an exposition of this theory of child development, see BAGLEY, W. C.—*The Educative Process.* New York: The Macmillan Company, 1905, pp. 185f.

[2] For expositions of this theory of child development see DEWEY, JOHN.—*How We Think.* Boston: D. C. Heath and Company, 1910, pp. 65–66. Also, THORNDIKE, E. L.—*Educational Psychology, Briefer Course.* New York: Bureau of Publications, Teachers College, Columbia University, 1914, pp. 107f.

The implications of these theories for education are so weighty that it is desirable to consider some experimental evidence bearing upon the question at issue.

**Evaluation of the opposed theories of mental development.**—Although the experimental evidence available does not afford a conclusive answer to the question concerning the nature of the order of development of mental traits, it does strongly suggest what the correct answer is. The results obtained by Pyle[1] from a group of tests given to subjects ranging in age from eight years to adulthood may first be considered. These tests included the following: (1) substitution, (2) logical memory, (3) rote memory, (4) cancellation, (5) free association, (6) controlled association, and (7) invention (formation of words from a given series of letters). The scores obtained on all the tests by persons of each chronological age level were combined into an average score for each age group, the scores for boys and for girls being kept separate. The results are shown in Figure 37.

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[1] Pyle, W. H.—*The Examination of School Children.* New York: The Macmillan Company, 1913. 70 pp.

It should be pointed out that some of the age groups were very small. Except in the case of logical memory, none of the groups contained as many as one hundred subjects, and in several cases, particularly at the upper

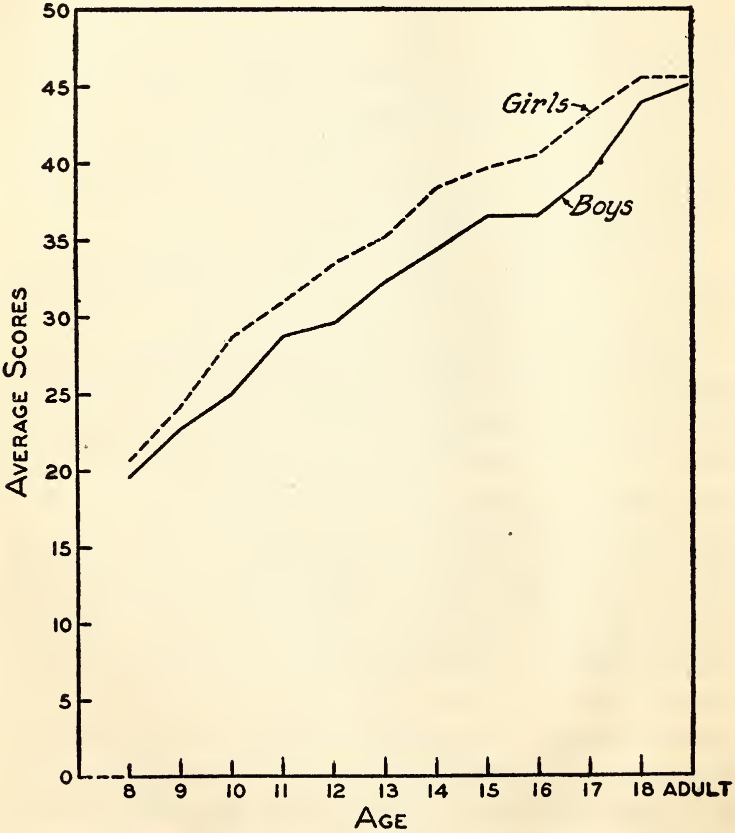

Figure 37. Mental Growth as Determined by Average Scores on Tests in Seven Functions. (After Pyle.)

age levels, there were fewer than twenty subjects. This fact, together with the additional fact that all mental measurements are unreliable in some degree, renders the results somewhat unreliable. In so far as they can be trusted, however, they indicate that the traits measured are nearly half as efficient in the eight-year-old as in the adult, and also that the yearly gain in efficiency between the two levels is fairly regular.

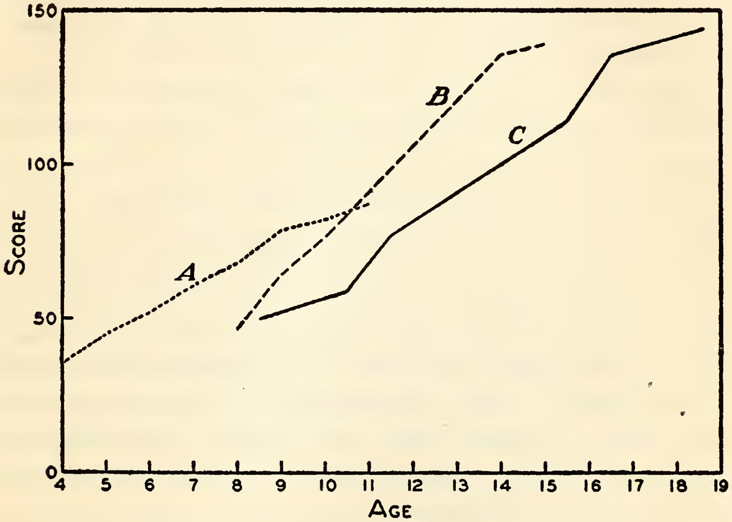

Figure 38. Mental Growth in Complex Functions.

Figure 38 shows the increase with age in the median scores made by large numbers of children on three tests of general mental ability. The abilities measured by these tests are among those ordinarily called the "higher," or more complex, abilities. The curves indicate that these abilities were present to a considerable degree among the youngest children tested, the lowest age being four years in one case and eight years and eight and one-half years in the other cases.

The evidence presented in Figures 37 and 38 is typical of a vast amount that has been accumulated. The age and grade norms for standardized tests show gradual rather than abrupt increases in achievement. The predominating view among psychologists is in agreement with Thorndike's statement that the available evidence does not justify the doctrine of a "sudden ripening" of capacities in a serial order.[1] Thus children may and do reason, but obviously they can reason only about childish things—that is, they can analyze, compare, generalize, etc., only within the limits of their experience. The reasoning of children differs from that of adults but the difference is to be found in the materials of thought (the data) rather than in the nature of the ideational activity.[2] The child thinks in terms of relatively concrete ideas; the adult in terms of abstractions, frequently in terms of symbols. In addition the adult has acquired general patterns of conduct such as the custom of suspending judgment, the critical attitude, and the like. Consequently it is to be expected that when compared with the reasoning of adults, the thinking of children appears so crude that it may not be recognized as reasoning.

**Theories concerning the influence of adolescence on the development of mental traits.**—Just as there are two opposed theories concerning the order of development of mental traits, so there are also two theories as to the manner in which the appearance of adolescence affects the development of these traits. These we may call the theory of saltatory development and the theory of gradual development.

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[1] THORNDIKE, E. L.—*Educational Psychology*, Vol. I. New York: Bureau of Publications, Teachers College, Columbia University, 1913, p. 261.

[2] DEWEY, JOHN.—"Reasoning in Early Childhood," *Teachers College Record*, Vol. 15, No. 1, pp. 9–15, January, 1914.

The proponents of the theory of saltatory development hold that the onset of adolescence is attended by a relatively sudden and rapid change in the development of mental traits. Adolescence, they say, can be regarded as nothing less than a "new birth," mentally as well as physically. At this time new traits appear and develop with leaps and bounds. The child acquires new interests, new attitudes, new powers, both physical and mental. Within a period of a few months he becomes a very different kind of individual, especially a very different kind of learner.

The advocates of the theory of gradual development hold, on the contrary, that no sudden and radical transformation occurs with the arrival of adolescence. The development of mental traits is essentially gradual, and the change that occurs during the first year of adolescence does not differ greatly from the change during any previous year. No new traits appear, and those which have been present during the preceding years continue to develop in much the same manner as formerly.

The theory of saltatory development, if it were accepted, would justify a rather radical change in the character of the subject matter selected and in the methods employed, both in teaching and in controlling the conduct of pupils, when the age of adolescence arrives. In particular, secondary education would properly differ widely from elementary education in these respects. The theory of gradual development, however, would require that the transition from one pedagogical level to another should at all times be gradual, and that no marked differences should be found between the last year of the elementary school and the first year of the secondary school.

**Evaluation of the theories of saltatory and of gradual development.**—If we refer again to Figures 37 and 38 and search for marked changes in the direction of the curves at the beginning of adolescence, which occurs at the age of twelve or thirteen for girls and a year or two later for boys, we fail to detect any marked changes at these age levels. The general direction of the curves is best described as a straight line. Brooks[1] has reported a study which may be summarized briefly as follows:

The subjects were 171 pupils in Grades IV–IX, ranging in age from nine to fifteen years. Twenty different tests were given during May in each of the years 1918, 1919, and 1920. In order to render the gains comparable, the gross gains on each test were divided by the average of the standard deviations of the scores made on the test by pupils of ages eleven, twelve, and thirteen. The resulting measures of improvement were assembled in four groups of similar functions and the average improvement was found in each group for boys and for girls at each age level. These four groups and the tests included in each were: (I) simpler functions—(1) number checking, (2) handwriting, including speed and quality; (II) memory functions—(1) immediate auditory memory of concrete words, (2) immediate auditory memory of abstract words, (3) memory for English equivalents of Italian words; (III) higher functions—(1) composition, (2) opposites, (3) directions, (4) substitution, digit-geometrical forms, (5) substitution, letter-digit, (6) reasoning, part of

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[1] Brooks, F. D.—"Changes in Mental Traits with Age," *Teachers College, Columbia University Contributions to Education*, No. 116. New York: Bureau of Publications, Teachers College, Columbia University, 1921. 86 pp.

Thorndike-McCall omnibus test, (7) language completion, (8) Thorndike Reading, Alpha 2; (IV) informational functions—(1) spelling, (2) Thorndike Reading $A_2$ and B-visual vocabulary, (3) Courtis arithmetic, (4) Woody arithmetic, series A, (5) Stone reasoning. The results are shown in Table XI. Inspection of the table shows that, in general, the amount of annual increase in these functions decreased with age from nine years to fifteen years. There is no evidence of marked increase in ability at the time of adolescence, save in the single case of the improvement by the boys in the simpler functions, where the gain from age thirteen to fourteen was 1.019 S.D.

TABLE XI. AVERAGE GAINS, FOUR GROUPS OF SIMILAR FUNCTIONS, IN TERMS OF THE AVERAGE S. D.
(From Brooks)

| AGES | SIMPLER | | MEMORY | | HIGHER | | INFORMATIONAL | |
|---|---|---|---|---|---|---|---|---|
| | Boys | Girls | Boys | Girls | Boys | Girls | Boys | Girls |
| 9 to 10 | .615 | .745 | .770 | .802 | 1.013 | .951 | 1.034 | .806 |
| 10 to 11 | .714 | .607 | .580 | .509 | .845 | .760 | .875 | .675 |
| 11 to 12 | .705 | .419 | .532 | .428 | .726 | .650 | .507 | .573 |
| 12 to 13 | .640 | .554 | .294 | .454 | .675 | .589 | .434 | .467 |
| 13 to 14 | 1.019 | .692 | .095 | .479 | .678 | .683 | .502 | .403 |
| 14 to 15 | .539 | .625 | .269 | .392 | .595 | .542 | .439 | .407 |

We conclude, then, that the development of mental traits from infancy to adulthood is, in general, in harmony with the theories of concomitant development and gradual development rather than with the opposed theories of serial and saltatory development. Any cases that may be at variance with this general principle are probably to be explained on the basis of the training received by the individual rather than on the grounds of innate tendencies toward development.

**Description of child development for pedagogical purposes.**—In school, pupils are classified for instructional purposes and hence there is need for a description of their characteristics at the various pedagogical levels. Before presenting descriptions based upon our present knowledge of child development, attention is called to certain earlier attempts. About 1900 a number of authorities advocated the culture-epoch theory. It was based upon an assumption of biological recapitulation, according to which the individual, in developing from the fertilized ovum to adulthood, was said to pass through all the stages of development that the race has passed through in its evolution from the simplest forms of life. This assumption was then carried over to the sphere of mental development, which was thought to repeat the stages through which the race has passed. Accordingly, the child is at one time a hunter, at another a nomad, at still another an agriculturist, and so on. According to the culture-epoch theory his training at each such stage should conform to his interests during that period. Rein, a follower of Herbart, applied this hypothesis and worked out a curriculum[1] for the German elementary schools.

Like some other theories, the culture-epoch theory becomes absurd when tested by common sense. Although the development of the child may parallel the development of the race in certain respects, it does not follow that the curriculum should parallel the cultural development of the race. Obviously a child living in the twentieth century should pursue a twentieth-century curriculum. There is no justification for delaying the study of current events and our present community, state, and national life until the child has completed his study of the preceding periods of racial development.

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[1] See Charters, W. W.—*Methods of Teaching.* Chicago: Row, Peterson and Company, 1912, p. 137. For a more elaborate application of the culture-epoch theory making industries the core of the curriculum, see Dopp, K. E.—*The Place of Industries in Elementary Education.* Chicago: University of Chicago Press, 1902. 270 pp.

Writing in 1905 Bagley stated: "As far as the educative process is concerned, however, the child is an entirely different being at different levels of his growth. Each period of development is marked by peculiar physical, mental, and moral characteristics that demand specific treatment." In order to provide a basis for discussing appropriate methods of teaching, he recognized three "distinct" stages of development: "(1) the *transition* stage from the age of six to the age of eight; (2) the *formative* stage, from eight to twelve; and (3) the *adolescent* stage, from twelve to eighteen."[1]

In 1911 Kirkpatrick[2] described six stages of child development: (1) pre-social stage, from birth to the end of the first year; (2) imitative and socializing stage, years 2–3; (3) individualizing stage, ages 4 to 6; (4) competitive socialization, ages 6 to 12; (5) pubertal or transitional, ages 12 to 18; (6) later adolescence, ages 18 to 24.

Kirkpatrick is careful to point out that the boundaries of each stage are not sharply defined nor uniform for all persons, and that the characteristics that are most prominent in any given stage are not to be regarded as being confined to that stage. He thinks that, although the order of development is less variable than the times of the various stages, there may even be variations in the order of the stages in the case of some children. In spite of these limitations, however, he believes that "it is possible to describe the inner and outer factors concerned and indicate what characteristics are likely to be prominent at any given age, with sufficient definiteness to help one in dealing wisely with children individually and in groups."[1]

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[1] Bagley, W. C.—*The Educative Process.* New York: The Macmillan Company, 1905, pp. 185, 186.

[2] Kirkpatrick, E. A.—*The Individual in the Making.* Boston: Houghton Mifflin Company, 1911. 339 pp.

The preceding discussion of growth, both physical and mental, indicates a lack of warrant for such an emphatic characterization of growth stages as proposed by Bagley or Kirkpatrick. No sharp, sudden changes in rate of development, either physical or mental, have been found, and hence there are no landmarks in the life of the individual to serve as definite boundaries for stages of growth. To attempt to erect such boundaries and to point out characteristics of each period that distinguish it from other periods invites the danger of exaggerating some traits and of minimizing others during the period in question.

**Levels of pedagogical development.**—From a pedagogical point of view, however, the life of the individual is broken up into a number of relatively distinct periods. It would be possible to describe his pedagogical progress year by year, but such a detailed account of normal achievement in each grade would be tedious and to no useful purpose here. We shall find it more appropriate for our purposes to consider the individual as a learner at the following levels of progress: I. Entrance to school (age 6); II. Intermediate grades (ages 9 to 11 ); III. Junior high school (ages 12 to 14); IV. Senior high school (ages 15 to 17 seventeen); and V. Adulthood.

The reader should constantly bear in mind that we are dealing in this chapter with average, or typical, cases. We have described physical growth in terms of average heights and weights at each age level, but there are, of course, wide variations in these respects among children of any given age. The situation is similar when the characteristics of children at various pedagogical levels are described. For example, the description of the typical child on entrance to school will by no means apply to all children. Some will exceed and others fall short of the level of development indicated.

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[1] KIRKPATRICK, E. A.—*The Individual in the Making.* Boston: Houghton Mifflin Company, 1911, p. 62.

## I. The Child on Entering School

**General physical status.**—The period of most rapid physical growth has been passed at the age of six years. The boy is now about forty-four inches in height and weighs about forty-three pounds, while the corresponding measures for the girl are approximately forty-three inches and forty-two pounds. The brain has attained about nine-tenths of its final weight. All of the milk teeth are present and the first permanent teeth (the first molars) will soon appear. The digestive system is farther advanced in its development than the other organs. The lungs and heart are relatively small, and hence the rate of pulse and of respiration is relatively high. The sensory apparatus is well developed and, unless defects are present, is functioning very efficiently.

**General mental development as shown by the Stanford-Binet Scale.**—Some notion of the general level of the child's mental development at this period may be obtained by noticing the tasks prescribed for this period in the Stanford Revision of the Binet-Simon Intelligence Scale.[1]

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[1] See pages 265f.

Moonlight Schools.

The tests for Year VI require him to: (1) distinguish right and left, in the case of his hand, ear, and eye; (2) tell what parts are missing in mutilated pictures of human faces and forms; (3) count thirteen pennies; (4) tell what he should do in such situations as "If it is raining when you start to school," or "If you find that your house is on fire"; (5) identify at least three of four coins—nickel, penny, quarter, dime; and (6) repeat a sequence of two sentences containing sixteen or eighteen syllables. The tests for the preceding year are: (1) to judge which of two weights—a three-gram and a fifteen-gram—is heavier; (2) to name the colors, red, yellow, blue, green when they are presented; (3) to tell which of two faces in pictures is prettier; (4) to define such common objects as chair, horse, fork; (5) to place two right triangles together so as to form a rectangle; and (6) to carry out a series of three commands in proper order.

Even a casual inspection of these lists of tasks reveals that the child who does them all satisfactorily—and the normal child is able to do most of them—gives evidence of having learned many things about persons and objects in his environment, of possessing some degree of power of judging, and of being able to attend to somewhat complex matters and to retain them in mind for at least a short period of time.

**Other effects of pre-school experiences.**—In addition to the pre-school development indicated by such tests of general ability as the Stanford-Binet, certain other acquisitions of the pre-school period are worth noticing. Of paramount significance is the child's progress in language. One investigator[1] finds that the average vocabulary of six-year-old children is 2,562 words, with a range of from 1,620 to 3,340 words. In some cases even larger vocabularies have been found. The ability to employ this number of symbols in oral communication is no mean achievement. Its true magnitude will be apparent to one who reflects upon the efforts required by a mature person in acquiring a similar degree of mastery of a foreign tongue. Perhaps no other fact speaks so convincingly of the child's proficiency as a learner as does his pre-school progress in language.

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[1] SMITH, M. E.—"An Investigation of the Development of the Sentence and the Extent of Vocabulary in Young Children," *University of Iowa Studies in Child Welfare*, Vol. 3, No. 5. Iowa City: University of Iowa, 1926.

The child's acquisitions in other respects than language are also important and of considerable magnitude, though on account of their not being so readily described in objective and detailed terms, they may appear less significant than his language growth. We have spoken in an earlier chapter[1] of the magnitude of the task of building the child's perceptual world, and need not dwell upon the topic here. It is apparent that a large portion of this development has occurred before entrance to school. No less an accomplishment is the progress that has been made in the direction of motor control. It is a long step from the helpless, random movements of the infant to the numerous motor activities of the six-year-old. Whereas the former is unable to change his position in space, much less to sit, stand, or walk, the latter moves about readily—walking, running, jumping, skipping, and in some cases even skating, swimming, and riding a bicycle. By the time of entrance to school, hand and eye coördination, which is wholly lacking in the infant, has been acquired to a considerable degree. The child can now roll a hoop, catch and throw a ball, and handle many objects to suit his purposes. Finer coördinations are as yet largely undeveloped, though some progress has been made, as is shown, for example, by the character of the child's drawings.[1]

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[1] Chapter V, pp. 158f.

The experiences of the pre-school period have also left their impress in the form of numerous habits and other controls of conduct, some of which are significant from the point of view of the school. Thus there are habits with respect to eating, sleeping, dressing, cleanliness, carriage and posture, and the like. At least the foundations for tendencies determining behavior in many relationships of life have been laid. The child can already be characterized with respect to his tendencies toward politeness, obedience to elders, treatment of other children, and so on.

**Characteristics as a learner.**—The child's craving for activity, both physical and mental, is an easily observable trait. His desire for physical activity is manifested in the great amount of play in which he engages. His nature rebels against inaction, and is not in harmony with the once-prevailing practice of forcing him to remain seated in the schoolroom for hours each day with a minimum of movement. Modern school practices wisely provide for a large amount of movement in the form of handwork, plays, games, physical exercises, and the like.

Curiosity and the resulting inquisitiveness seem to be typical of children unless these traits are subdued by unwise treatment in the home or the school. Kirkpatrick lists eighteen questions which one boy asked about an airship. These included: "How high will it go? . . . How big is it? Where does the man stay that makes it go? What kind of an engine does it have? . . . How much gas does the airship hold? . . . How much does it cost?"[1]

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[1] One of the tests for Age IV on the Stanford-Binet Scale is to produce an acceptable copy of a square.

The range of stimuli that elicit spontaneous attention in the child is very wide. It is a mistake, however, to suppose that he is incapable of voluntary attention. It is true that capacity for sustained voluntary attention is a mark of mental maturity, and should not, therefore, be expected of the young pupil. Drummond[2] says that at the age of six attention can be fixed for fifteen minutes; at seven to ten, for twenty minutes; at ten to twelve, for twenty-five minutes; and at twelve to fourteen for thirty minutes.

One of the most important characteristics of the child as a learner is his plasticity—that is, the readiness with which new neural pathways may be opened up, or new neural connections formed. At a later point in the chapter we shall consider the adult's capacity for learning, and shall point out that the degree of plasticity yet remaining in adulthood is greater than has often been supposed, but it cannot be doubted that the plasticity of the child exceeds that of the adult.

## II. The Pupil in the Intermediate Grades

**Physical traits.**—There is a slight decrease in the rate of growth during the intermediate grades. Accompanying this decrease in the rate of growth is an unusual store of energy and vitality. The child is more active now than at any other time in life. He is comparatively immune from diseases and, if he becomes fatigued, he recuperates very quickly. Brain growth has practically ceased.

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[1] Kirkpatrick, *op. cit.*, pp. 161–62.

[2] Drummond, W. B.—*An Introduction to Child-Study.* New York: Longmans, Green and Company, 1912, p. 181.

**General mental development.**—It will be helpful to compare the tasks included in the Stanford-Binet tests for the years nine and ten with those mentioned in describing pre-school development.[1] Among others, the following are now within the limits of his ability: (1) to discriminate differences among weights of 3, 6, 9, 12, and 15 grams; (2) to construct a sentence, using three assigned words—as, boy, river, ball; or work, money, men; (3) to name the months of the year in correct order; (4) to point out the absurdity in such a statement as "An engineer said that the more cars he had on his train the faster he could go"; (5) to reproduce two designs which he has observed for ten seconds; (6) to read satisfactorily a short paragraph and then tell at least eight things included in it; (7) to respond to "What ought you to say when someone asks your opinion about a person you don't know very well?"; and (8) to repeat a sentence containing twenty or twenty-two syllables.

Hollingworth[2] speaks of the development of certain more specialized mental traits at this period as follows: "Intellectually many forms of dexterity approach their maximum at this time; processes of sensory discrimination, immediate memory, retention span, sensori-motor reaction times—these change little if any, as the result of increasing age, after this period."

**Changes in social attitudes.**—In contrast with the strong tendency toward imitation of others possessed by the child when he first enters school, his dominant trait at this later period is usually designated as his tendency toward competition. He no longer engages chiefly in individual play, but enters into competition with his fellows in his games. Judd says of the child at this period: "The readjustment which comes at this point can be described by saying that the pupil is entering on a period of self-recognition. . . . The boys of this period have been described as young barbarians. They are disregardful of the rights of others. They step on the little children; they refuse to be friends with the girls. They are ambitious to leave school and to do something to assert their independence."[1]

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[1] See pages 411f.

[2] Hollingworth, H. L.—*Mental Growth and Decline.* New York: D. Appleton and Company, 1927, p. 191.

**Pedagogical development.**—The most significant phase in the development of the child as a learner is his acquisition of the fundamental processes or tools of learning. He becomes able to engage in reading as a learning activity, and makes use of this activity to acquire knowledge in geography, in history, and in other fields. He learns to write and to spell. He learns many of the conventionalities of our language. He learns to calculate. He learns a relatively large number of fundamental facts about his environment, and acquires an extensive foundation of perceptual experiences. Of course at the end of his eleventh year he is still immature in many respects, but he is very different as a learner from what he was during the earlier period.

## III. The Junior-High-School Pupil

**Physical traits.**—This period, as we found earlier in the chapter, is marked by a slight increase in the rate of growth in height and a much more noticeable increase in the rate of growth in weight. These increases occur a year or two earlier in girls than in boys. Due to this rapidity of physical growth, the period is often referred to as the "awkward age."[1] Tyler[2] describes the growth of this period and its effects upon the child: "Walking must be learned almost anew. This is no easy matter. The boy stumbles over his feet, and the girl is ungraceful. . . . Neither of them knows what to do with hands and arms." Judd[3] points out that "The whole life of the individual is intensified. It is not alone the sex organs which mature; the nervous system acts with greater energy, and the muscular system develops."

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[1] Judd, C. H.—*Introduction to the Scientific Study of Education.* Boston: Ginn and Company, 1918, p. 189.

**Changes in social attitudes.**—Significant changes in the child's tendencies toward social behavior are observable during this period. The competitive spirit during the preceding period is chiefly individualistic in character. The child at that level strives for individual success and distinction. During the junior-high-school period, however, he shows stronger tendencies toward team work and coöperative contests. He is now elated at the victory of his team, or is proud of the showing made by his grade group or his school. In short, he is beginning to subordinate himself to the group of which he recognizes himself as a member.

The changed attitude of the sexes toward each other is also noticeable. Each is becoming more interested in and tolerant of the other, although this change in attitude may be held in secret reserve in many cases. Thus, even though the boy may affect a contempt for girls, he nevertheless is at pains to "show off" in their presence. He envies the larger boys who may openly manifest their admiration for the opposite sex without fear of criticism, and longs for the arrival of his own maturity when he will enjoy all the pleasures and privileges that the adult and the near-adult enjoy.

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[1] For example, HOLLINGWORTH (*op. cit.*, Chapter XII) thus names the entire period from the twelfth to the eighteenth year. His chapter on this period is well worth reading.

[2] TYLER, J. M.—*Growth and Education.* Boston: Houghton Mifflin Company, 1907, pp. 158–59.

[3] JUDD, *op. cit.*, p. 191.

His deeper insight into social situations and increased power to interpret them is very significant. One of the Stanford-Binet tests for the twelfth year is the interpretation of such fables as the ones entitled "Hercules and the Wagoner" and "The Farmer and the Stork." Terman[1] finds that at the mental age of twelve the child is, for the first time, able to generalize on the basis of such social situations as are presented in the fables.

**Pedagogical development.**—The work of the first six years of the school has resulted in considerable progress toward the mastery of the processes of reading, writing, spelling, and arithmetic as well as in some knowledge of history, geography, hygiene, nature study, and the like. On page 417 the pupil completing the sixth grade was described as having acquired the fundamental process of reading. Although this statement is true in one sense, it is not true if "acquired" is interpreted to mean "complete mastery." The sixth-grade pupil has learned to read, but he is not a *good* reader of much of the material he will be asked to read in his future school work. This statement is in agreement with both the observations of high-school teachers and the results of scientific investigations. For example, in a recent investigation,[2] a type of reading ability designated as "literary comprehension" was measured by means of five tests based on a given selection.

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[1] TERMAN L. M.—*The Measurement of Intelligence.* Boston: Houghton Mifflin Company, 1916, pp. 297f.

[2] IRION, THEO. W. H.—"Comprehension Difficulties of Ninth-Grade Students in the Study of Literature," *Teachers College, Columbia University Contributions to Education*, No. 189. New York: Bureau of Publications, Teachers College, Columbia University, 1925. 116 pp.

Test 1. Reading Comprehension (broad): In this test the student was asked to check in a list of statements the ones that seemed to represent the most important conclusions in the selection, and also the ones that seemed to represent the most important points made by the author in the "development of the thought of the story."

Test 2. Fact Comprehension: This test consisted of ten fact questions each of which was to be answered by checking the best answer in a list of five statements.

Test 3. Expression Comprehension: This test consisted of ten expressions taken from the selection. The student was asked to check in given lists the statements that seemed to be the best explanation of the expressions.

Test 4. Word Knowledge: In this test the student was required to indicate the meaning of twenty words taken from the selection by checking in a list following each word the word or expression "which means most nearly what the first word of that line means, as used in this story."

Test 5. General Information: This test consisted of twenty questions concerning biography, history, geography, and so forth. The information tested may be described as forming the background of the selection.

Four such series of tests were given to 170 representative ninth-grade students. The investigator states the following conclusion:

> The average reading comprehension as compared with the total reading comprehension possibilities of the selections used is so mediocre that it is very hazardous to proceed on the assumption that students in the ninth grade can read well enough to comprehend and appreciate literature by merely reading.[1]

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[1] Irion, *op. cit.*, pp. 71–72.

See also Judd, C. H, and Buswell, G. T.—"Silent Reading: A Study of the Various Types," *Supplementary Educational Monographs*, No. 23. Chicago: University of Chicago, 1922, pp. 44–45.

The situation relative to the other fundamental processes is more satisfactory, but junior-high-school teachers should bear in mind that when we describe the junior-high-school pupil as having acquired the fundamental processes, the statement is not entirely true. A more precise statement would be that the pupil has progressed in his learning to the point where he is able to use the fundamental processes as tools of learning to a much greater extent than formerly, but that he needs to continue his acquisition of fundamental processes, especially reading. It may be noted that some of the needed training in the fundamental processes will be secured by using them as tools of learning. Perhaps most of it can be secured in this way, but it is dangerous for the teacher to assume that the junior-high-school pupil has attained that stage in his education in which no explicit attention needs to be given to the fundamental processes.

## IV. The Senior-High-School Pupil

**Physical traits.**—During this period the pupil approaches physical maturity. By the end of the senior-high-school age the rate of physical growth is markedly reduced. In fact, in the case of girls there is relatively little increase during the period. Boys are still making gains in height and weight, but they are approaching the age when the rate of increase will decline. Other physical traits, such as size of the heart, lung capacity, and strength of grip, also approach their adult limits.

**General mental development.**—As in the case of the physical mechanism, the pupil's mental development approaches close to the adult level during this period. The Stanford-Binet test for Year XVI is called the "Average

Adult" test, and the test for Year XVIII, the "Superior Adult" test. This implies that native intelligence does not improve after the age of sixteen. Many psychologists now believe there is some gain in capacity to learn after this age, but it would probably be generally agreed that there is but little increase, if any, after the senior-high-school period.[1]

**Social characteristics.**—The pupil's consciousness of his approach to mature estate, both physically and mentally, is reflected in his estimate of himself and in his attitude toward his elders. He exhibits an increased interest in the affairs of adult life and an independence of judgment with respect to them. He will no longer submit unquestioningly to those in authority, especially if he feels that demands for submission are purely arbitrary.

There is, of course, a greater degree of mutual attraction between the sexes than has hitherto existed. Furthermore, there is now less hesitation about manifesting interest in one of the opposite sex, as well as a larger measure of freedom in associating with such a one. Consequently social life takes on a wholly different color during this period and assumes far larger proportions in the thinking and the interests of the pupil.

**Pedagogical characteristics.**—The changed status with respect to the physical, intellectual, and social characteristics mentioned in the preceding paragraphs is inevitably reflected in the pupil's traits as a learner. The following traits of the pupil should be recognized by those who are responsible for his training during this period:

1. Since, during this period, his capacity to learn reaches or closely approximates its maximal development

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[1] See pages 262f.

the pupil is now nearly as capable as he will ever be of pursuing studies that require a rather high degree of ability to deal with abstractions, to arrive at generalizations, and to follow relatively long trains of logical thought. Some subjects that could hardly have been pursued with pleasure and profit at an earlier period are now in order, provided the pupil can be brought to apply himself seriously to the task of mastering them. These more difficult subjects include algebra,[1] geometry, physics, chemistry, and economics.

2. The senior-high-school pupil *should* be approaching complete mastery of the fundamental processes.[2] Especially, he *should* have become proficient in reading, since his training up to this point has afforded abundant opportunity for acquiring skill in this process. His power to learn has been increased, not only by his better command of the tools of learning, but also by reason of the fact that he has at least a slight acquaintance with, and some measure of insight into, various fields of knowledge—provided the introductory and exploratory functions of the junior high school have been fulfilled. His fund of knowledge has also been enlarged by his extra-school contacts. These contacts, moreover, because of his deeper insight into matters of daily experience, are far more meaningful to him than to a younger person.

3. The senior-high-school pupil's increased interest in social activities involving persons of the opposite sex and his fondness for athletic activities result in a greater variety of interests than characterizes the younger pupil.

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[1] It will be helpful in this connection to consult page 516 for a discussion of the level of ability necessary for success in algebra.

[2] The word "should" is used advisedly. At present many senior-high-school pupils do not approach complete mastery of the fundamental processes.

It frequently appears that the pupil in the senior high school is, relatively speaking, far less interested in academic pursuits than he was during the earlier periods of school life. Other interests now clamor for, and receive, an increased share of his attention.

4. During the earlier periods of his pedagogical progress, the pupil lived largely in the present with but little concern for the distant future, but now at the senior-high-school level he is taking thought for the years ahead. In many cases definite vocational choices are made, but even if the pupil is undecided as to the nature of his life work, he is at least influenced in some manner by his consciousness of the fact that adulthood with its opportunities and its responsibilities is just across the threshold. This concern about the future, however, does not necessarily operate to produce vigorous application to each and every school subject. Many pupils are convinced that high-school graduation is necessary for the realization of their purposes, but do not feel that a particular subject of study is important for them. Many have a general faith in the worthwhileness of high-school training, but do not in consequence set a high value upon particular subjects such as algebra, or Latin, or botany, or English.

5. One important characteristic of high-school pupils taken collectively is the wide range of capacity found in them. On the assumption that the I.Q. is approximately constant,[1] it is evident that relatively small differences among children at the time they enter school are considerably magnified by the time they reach the senior high school. Thus, a year's difference in mental age at the chronological age of six becomes a difference of three years

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[1] See Chapter VIII, pages 291f.

at the age of eighteen. There is, of course, some elimination of children—usually of those of inferior capacity—before the senior-high-school period is reached; but many of those who are below the average in intelligence continue through high school. The result is that many of the pupils have not reached, and never will reach, the level of mental development necessary for the successful pursuit of many of the subjects included in the high-school program of studies.

**The adult as a learner.**—The belief is widespread that childhood is the period of learning, and that as a rule adults learn slowly and only as the result of much effort.[1] Until recently there has been no systematic and extensive inquiry into the facts of adult learning. After such an inquiry Thorndike and his co-workers have concluded that the ability to learn possessed by adults up to the age of forty-five is only slightly less than that of children. "In general, teachers of adults of age 25 to 45 should expect them to learn at nearly the same rate and in nearly the same manner as they would have learned the same thing at fifteen to twenty."[2]

In describing pupils at the various pedagogical levels, attention has been called to the degree of their mastery of reading as a tool of learning. A few adults are expert readers; but the results of a reading test administered to a select group—say of college students—show very marked individual differences, and that a considerable number are poor readers. In a recent investigation[1] of reading ability possessed by students in educational psychology, it was shown that the "poorest readers" when "working to full capacity" "are comprehending only about twenty to thirty per cent of the more difficult material and from fifty to sixty per cent of the easier material."[2]

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[1] This belief has been shared by many psychologists. See JAMES, WILLIAM.—*Principles of Psychology*, Vol. II. New York: Henry Holt and Company, 1890, p. 402. HOLLINGWORTH, H. L.—*Mental Growth and Decline.* New York: D. Appleton and Company, 1927, pp. 310f.

[2] THORNDIKE, E. L., and others.—*Adult Learning.* New York: The Macmillan Company, 1928, pp. 177–78.

**Age-changes in ability to learn.**—According to Thorndike,[3] ability to learn increases rapidly during the period of elementary education. It continues to increase, though at a decreasing rate, until about the normal age for graduation from college. After this maximum is attained, there is a decrease in ability to learn; but the decline is relatively slight, being not more than 13 to 15 per cent at the age of forty-two.

In explaining these age changes in ability to learn, Thorndike considers ability to learn as a resultant of six factors: (1) "inborn capacity to develop the ability to learn"; (2) "the extent and manner in which inner growth of the ability to learn has proceeded in each one's case"; (3) "a possible degenerative effect of late age"; (4) "training in specific habits of learning";[4] (5) "training in study habits and other general patterns of conduct, or modes of response that affect learning"; (6) forgetting.[5] "Inner growth" appears to continue until about the age of twenty. Very little is known concerning the "degenerative effect

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[1] Anderson, E. M.—"Individual Differences in the Reading Ability of College Students," *University of Missouri Bulletin*, Vol. 29, No. 39, Education Series No. 25. Columbia: University of Missouri, 1928. 77 pp.

[2] *Ibid.*, p. 53.

[3] Thorndike, E. L., and others.—*Adult Learning*. New York: The Macmillan Company, 1928, pp. 126f. See also p. 147.

[4] These include the so-called tools of learning of which reading is the most important.

[5] Thorndike's expression is "the general effect of the lapse of time without use upon acquired abilities." *Ibid.*, p. 128.

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of late age," but it probably does not become an important factor until relatively late in life. It appears that after the "inner growth" ceases, age-changes in ability to learn, up until past middle age, are due almost wholly to the last three factors. The fourth and fifth factors operate to increase ability to learn and the sixth to decrease it. Any decrease in ability to learn from about twenty until middle age or after is due largely to forgetting "specific habits of learning," and study habits and other general patterns of conduct that affect learning. In most cases forgetting the latter type of controls of conduct is probably the most important cause of a decline in ability to learn during this period.

**Ability to learn versus amount learned.**—The reader should note that the preceding paragraphs have been concerned with "ability to learn" rather than the "amount learned." The "amount learned" at any age depends upon factors other than "ability to learn." They include general health and energy, interest in learning, and opportunities to learn. In general it appears that a decline in amount learned is due primarily to the last two of these factors.[1]

**Concluding statement.**—In this chapter an attempt has been made to describe the main features of the child's development, both physical and mental, from the early years of life to adulthood. The process of growth has been characterized as gradual and continuous thoughout the entire period of formal education. Much progress has been made before the child enters school. The pupil is a perceiving, remembering, imagining, thinking individual, with a distinct personality, and with characteristic attitudes and tendencies toward definite patterns of response.

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[1] For a discussion of this topic see Thorndike, *op. cit.*, pp. 146f.

All these traits should be recognized throughout the child's school life. At no time should one type of response be emphasized to the neglect of the other types. There is, however, at any given point in his development, a limit to his ability to respond in any given manner, and the demands placed upon him at any time should not exceed this limit. He may be able to lift a hundred-pound weight when he is in the junior high school, even though he is unable to lift it when he is in the primary grades. It may be possible for him to construct a proof of a proposition in geometry when he is in the senior high school, but altogether impossible for him to do so when he is in the intermediate grades.

Since the child changes as a learner during his school career, it is appropriate to inquire concerning the educational significance of his development. Is there a *natural* order of school subjects? Are the characteristic traits of a given age an index of the topics and subjects that should be studied at that period of the child's development?

Although curriculum authorities do not agree in regard to the answers to be given to these questions, it seems certain that the child should be considered in organizing the curriculum. Other factors, especially the demands of out-of-school life, should also be considered, but the child should not be neglected. In this connection Judd[1] points out that nature study has been unsuccessful in the elementary school because the pupils have not yet acquired a "scientific attitude toward the world about them," and because they are more interested in the behavior of animals than in their structure or biological history.

Just what training should be given at each pedagogical level depends upon many factors, of which the nature of the pupil is one. It is the task of the educational theorist to take account of all the factors involved and to deduce therefrom the proper conception of what education should be. It is the task of the educational psychologist to supply the theorist with an adequate description of those characteristics of the pupil to which the proposed training must conform. Unfortunately, in spite of the vast amount of time and effort that have been devoted to child-study, an adequate description has not yet been provided.

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[1] Judd, C. H.—*Psychology of Secondary Education.* Boston: Ginn and Company, 1927, p. 45.

## LEARNING EXERCISES FOR THE READER

1. Can you cite instances of reasoning by young children?
2. Explain clearly why the two questions raised in the first paragraph of this chapter are of importance to education.
3. Assume that you have been asked to read a paper before a meeting of a parent-teacher's association on the subject, "The Educational Significance of the Child's Pre-School Life." Prepare the paper you would read.
4. Explain the gap in each of the curves in Figure 35.
5. Why cannot an adequate description of mental growth be given at present?
6. If the recapitulation theory is accepted, does the culture-epoch theory necessarily follow? If the former is rejected, is there any warrant for the latter?
7. Prepare a report on the child-study movement.
8. Does it seem to you, from your observations, that the period of adolescence is likely to be attended by radical changes in the fundamental traits of character?
9. Is the person who accepts the theory of serial development likely to accept also the theory of saltatory development? Is he certain to do so? Explain.
10. Is the present organization of education in this country more in accord with the theories of periodic and saltatory development than with the opposed theories? Explain.

11. Illustrate graphically age-changes in ability to learn, basing your figure on statements found on page 426.

12. Does it seem to you, from the descriptions of pupils at the different pedagogical levels, that, aside from knowledge of the subjects taught, the characteristics of the teacher in the senior high school should be materially different from those of the teacher in the elementary grades?

{ Psychology of Elementary Education
brary { " " " School Subjects

# CHAPTER XII

## THE PSYCHOLOGY OF ELEMENTARY-SCHOOL SUBJECTS

**Introductory statement.**—The chief concern of educational psychology is the learning process. Our treatment of the subject up to this point has consisted largely of a consideration of the following questions: How may the child's original nature, with which his learning must begin and by which it is greatly influenced, be described? How does original nature, and hence learning, vary among individuals? What various types of responses does the pupil make in learning? What determines, or controls, these responses? What laws and principles govern the learning process? What are the effects, or outcomes, of learning? How may these effects, as well as native capacity for learning, be measured?

The consideration of these questions has been general in character; that is, the facts, principles, and laws discussed are applicable to all learning. The teacher, however, is usually engaged in directing learning in some particular school subject. He is concerned with learning as it occurs in arithmetic, or spelling, or reading, or geometry rather than with learning in any general and abstract sense. He is confronted, therefore, with the problem of applying the psychological facts, concepts, and principles he has acquired to the situation in which a group of flesh-and-blood pupils are engaged in learning history, music, Latin, or some other school subject. This application, we may add, is not always easily made.

If we restrict such questions as those mentioned in the first paragraph of this chapter to the field of a given school subject, the answers to them may be said to constitute the psychology of that particular subject. The extent to which educational psychology will be of practical value to the teacher depends in large measure upon his ability to answer these questions with respect to each subject he teaches. Unfortunately, our answers are not, at present, wholly complete and satisfactory. Furthermore, it is impossible to present in this volume all that is known about the psychology of each of the various subjects. Hence we must be content with a brief discussion of some of the more important aspects of a limited number of school studies.

In the present chapter a brief treatment of each of the following elementary-school subjects is presented: (1) handwriting, (2) reading, (3) arithmetic, and (4) spelling. The following chapter will deal with certain high-school subjects: (1) algebra, (2) geometry, (3) English composition, (4) the natural sciences, and (5) the social sciences. The emphasis in each case will be placed on the nature of the learning activities in which the learner engages, but some attention will be given to other matters, particularly the nature of the outcomes of the learning.

These chapters should serve a twofold purpose. In the first place, it is hoped that the material presented in them will, in and of itself, be helpful to teachers. In other words, the two chapters will in some measure make the application of general educational psychology to the particular fields of the subjects treated and thus give the teacher a deeper and clearer insight into the problems of directing the learning of these subjects. In the second place, the chapters should serve to illustrate the manner in which, or the methods by which, the teacher himself may extend the application of educational psychology to other subjects of instruction. He should be led to analyze more completely the learning involved and to determine more sagaciously the proper teaching procedures.

## I. HANDWRITING

**Handwriting an illustration of sensori-motor learning.**—Handwriting furnishes an illustration of sensori-motor learning.[1] Usually the child who is beginning to learn to write is able to make each of the muscular responses involved in holding the pen and in moving its point over the paper, but he is not able to combine them in a coördinated series such that legible writing is produced. Furthermore, the beginner makes many useless movements—such as contracting certain muscles of the face, twisting the body, and perhaps clenching the left hand. Hence learning to write involves selecting the movements required for producing the desired letter forms, and combining and coördinating them so that the pen point will be moved rapidly over the paper forming correctly the words being written. In the mature writer, the necessary coördinations have become so thoroughly fixed that little or no attention is given to them in the act of writing. As such a writer thinks of the successive words in a sentence, the writing movements occur automatically except when impeded by spelling difficulties or other difficulties.

**Movements employed in handwriting.**—The total writing movement requires the coöperation and coördination of a great number of muscles. First, there are the movements involved in producing the letters when the hand is kept at a given point along the line. Secondly, there are the movements employed in carrying the hand along the line. Finally, many persons employ a third type of movement, called pronation, which consists in gradually rotating the hand to the left as it moves along the line; a movement that compensates for the increase in slant which appears toward the right end of the line when pronation is not present.

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[1] See pages 152f.

If the movements of an unskilled writer are observed, it will usually be found that he makes as many letters as he can without moving the hand along the line, then pauses in the process of forming letters and shifts the hand to another point to the right. He again makes all the letters he can in this position, and again pauses and shifts the hand. As a consequence of his inability to maintain a constant sliding movement of the hand across the page, his hand is brought into a cramped position before each shift and the movements made in forming the letters are not easy and free. Skill in handwriting requires that the three movements mentioned in the preceding paragraph be properly combined into one smooth, continuous performance; that is, the hand must be carried along the line while the letters are being formed, and all the while the proper modification of the angle formed by the plane of the wrist and the writing surface should be made.

If left without guidance in writing, the child uses finger movements in forming the letters. Some authors of penmanship systems have insisted that all finger movements should be prevented, or eliminated if once adopted, and that all the movements be controlled by muscles above the elbow. The fingers, therefore, would only hold the pen and not move it to form the letters. It appears, however, that the finer muscles of the forearm can more easily be called into service in performing the rather delicate movements in letter-formation than can the coarser muscles above the elbow. Although it is possible, if sufficient practice is given, to learn to perform all the writing movements without any movements of the fingers, most persons later return to some use of the fingers in forming the letters. The arm movement is essential in carrying the hand along the line and may assist in making the longer strokes in letter-formation, but the fingers may well coöperate in the finer movements.

**Early stages of learning to write.**—A child may make a beginning in learning to write by attempting to imitate the movements of another person, but, as pointed out on page 433, his movements will include a number that are useless and may not include some that are essential. Furthermore, his movements will not be coördinated so that letters are formed correctly. Teachers of handwriting have devised several systems of exercises designed to facilitate the learner in selecting and coördinating the necessary movements. The traditional method included demonstrations by the teacher and a model of writing which the pupil was asked to imitate. Sometimes the teacher grasped the pupil's hand and put it through the writing movements. In some schools the pupils are asked to trace with a pencil letters and words carved in grooves. Another procedure is to have the pupil trace a model copy on transparent paper.

A recent investigator[1] has endeavored to ascertain the relative merits of four methods: (1) groove tracing, (2) tracing a model copy on transparent paper, (3) imitating a model copy placed above the practice paper, and (4) a combination of these three methods. The results of the experiment indicate that children improve most when introduced to writing by means of the third method.[1] The writer points out that this conclusion is in agreement with another study[2] and also with Thorndike's theory of transfer through identical elements.[3]

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[1] Hertzberg, O. E.—"A Comparative Study of Different Methods Used in Teaching Beginners to Write," *Teachers College, Columbia University Contributions to Education*, No. 214. New York: Bureau of Publications, Teachers College, Columbia University, 1926. 61 pp.

Much of the child's writing during the first year may well be done on the blackboard, since in this way the free movements of the muscles of the upper arm and shoulder will be encouraged. His writing at the desk should be done with a large pencil and on widely ruled paper. Although the time should be spent chiefly in writing letters, figures, and words rather than in movement exercises, the development of coördinated movements should occupy an important place in the aims of the instruction during the year.

The perception of the forms that the learner is to attempt to reproduce is, of course, an important step in beginning to learn to write. The child must be assisted in making some analysis of the forms in order that he may perceive them with some degree of accuracy. His attempts at reproduction are predominantly a process of trial-and-error learning, but demonstrations supplemented with appropriate directions and suggestions may serve to reduce the amount of trial-and-error procedure that would otherwise be excessive.

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[1] Hertzberg, *op. cit.*, p. 57.

[2] Gates, A. I., and Taylor, G. A.—"The Acquisition of Motor Control in Writing by Pre-School Children," *Teachers College Record*, 24:467, November, 1923.

[3] See pages 236f.

**Practice in handwriting.**—The perfecting of the coördinated series of movements involved in handwriting is accomplished only by means of extended practice. Even under the most effective instruction, the first attempts of the pupil will involve superfluous movements and other imperfections which must be eliminated largely through the "trial-and-error" method.[1] Oral suggestions and demonstrations by the teacher frequently are helpful, but the pupil's improvement is dependent upon his participation in appropriate learning activities which in this case should be confined largely to attempts to write. As is always the case in practice, mere repetition does not guarantee improvement.[2] Practice brings the largest measure of improvement only when the learner has a clear idea of the results to be attained, becomes aware of his errors, and experiences satisfaction when he is aware that he is making progress toward the end in view.

The most desirable length of practice periods cannot be stated with certainty, but it is probable that practice should not continue longer than ten or fifteen minutes at a time during the early stages of learning. Perhaps twenty minutes should be the maximum length of the periods during the later years of the elementary school.

It is generally accepted as a valid principle in sensorimotor learning that the emphasis in instruction should be placed on the results desired rather than on the movements to be performed in order to produce these results. When attention is called to the movements, it should be to the movements to be made rather than to those to be avoided. Whatever movement predominates in consciousness is most likely to be performed.

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[1] See page 153.

[2] See page 189.

**The objective of formal training.**—Perfection in handwriting is not desirable, since it would be purchased at too great a cost. Relatively few pupils reach the quality of 90 on the Ayres Scale,[1] but fortunately it is not necessary that this quality be attained. Competent judges have decided that a quality of 60, or 70 at most, on the Ayres Scale, or of 11 or 12 on the Thorndike Scale, is satisfactory for practically all purposes. When a pupil has acquired the ability to produce handwriting of such quality at the rate of approximately seventy letters a minute, he should be excused from further training in penmanship. Freeman[2] believes that, in the case of most children, this result can be attained by the end of the sixth grade. Proficiency in writing, however, requires that the performance be carried on practically automatically, with the attention wholly fixed upon the thought to be expressed. It may be well to add, therefore, that the rate and quality specified above should characterize the pupil's writing even when no attention is given to the process.

**Scales for measuring ability in handwriting.**—A number of scales have been constructed during the past twenty years for measuring the quality of handwriting, but attention will be called here to only a few of the best known and most widely used ones.[3] Two important types of scales should be distinguished. One may be called the "general impression" scales, which are used in estimating the general quality of a sample of handwriting by comparing it with a series of samples arranged in order of merit on the scale. These scales are relatively simple to use, though some practice is usually necessary before reliable ratings can be made with them. They are useful instruments for obtaining a general rating of quality for the purpose of comparing one pupil's handwriting with another's or with the norm for his grade. Among the scales of this type may be mentioned the Thorndike Scale[1] and the Ayres Scale.[2]

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[1] See page 439.

[2] Freeman, F. N., and Dougherty, M. L.—*How to Teach Handwriting.* Boston: Houghton Mifflin Company, 1923, p. 24.

[3] For a more extended account consult the following reference or some other text on educational measurements. Monroe, Walter S., De Voss, J. C., and Kelly, F. J.—*Educational Tests and Measurements* (Revised and Enlarged Edition). Boston: Houghton Mifflin Company, 1924, pp. 166–72.

The Thorndike Scale is composed of samples of handwriting numbered from zero to eighteen, the various steps (or intervals) denoting approximately equal increments of quality. The specimen of zero quality is an attempt at writing, but is wholly illegible, while quality eighteen is a specimen of perfect writing. The Ayres Scale contains specimens at eight levels of quality. These are numbered 20, 30, 40, and so on up to 90.

A different type of handwriting scale is the analytical scale, or more properly a group of scales, each one of which measures only one aspect, or element, of handwriting. Freeman's Scale[3] is a composite of five divisions for rating separately the following elements of handwriting: (1) slant, (2) alignment, (3) quality of line, (4) letter formation, and (5) spacing, both between letters and between words. A single quality rating may be obtained by combining the five separate ratings. The chief merit of such a scale, however, is found in the service it renders in indicating, more specifically than does the general scale, the nature of the defects of the specimen that is being rated.

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[1] THORNDIKE, E. L.—"Handwriting." *Teachers College Record*, Vol. II, No. 2. March, 1910.

[2] AYRES, L. P.—*Measuring Scale for Handwriting*. New York: Russell Sage Foundation, 1912. This is the three-slant edition. The "Gettysburg Edition," 1917, has only one specimen at each level of quality.

[3] FREEMAN, F. N.—*The Teaching of Handwriting*. Boston: Houghton Mifflin Company, 1914, pp. 123–42, and appendix.

**Relation between rate and quality.**—Rate and quality of handwriting, in the case of an individual pupil, are inversely related. If one writes faster than his normal rate the quality of his writing is lowered. If he attempts to produce writing of the best quality possible for him, the rate will be decreased. In other words, if either rate or quality is over-emphasized, it will be at the expense of the other. A fault of the former copybook method consisted in the improper emphasis on form and the neglect of rate.

Rate and quality should be developed together. The beginner should not be urged to write too rapidly nor expected to write as fast as the pupils in later grades. Freeman[1] suggests standards of twenty letters a minute by the end of the first year and seventy letters a minute at the close of the sixth grade.

**Correlation of ability in handwriting with ability in other subjects.**—Thorndike[2] has reported that, in the case of adults, there is no correlation between ability in handwriting and general scholarship. Starch[3] found a correlation of .31 in the case of children. This may be explained by the reasonable assumption that the pupils who do the best work in other subjects tend to put forth more effort in learning to write than do the poorer pupils.

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[1] Freeman, F. N., and Dougherty, M. L., *op. cit.*, p. 35, 263.

[2] Thorndike, E. L.—"Handwriting," *Teachers College Record*, Vol. II, No. 2. March, 1910.

[3] Starch, Daniel.—"The Measurement of Efficiency in Handwriting," *Journal of Educational Psychology*, 6:106–14, February, 1915.

Peripheral - sensori- works on sense cel
entral never works on sense organ

## II. Reading

**The general nature of silent reading.**—The act of silent reading involves (1) the perception of printed words and phrases, (2) the recognition of these symbols, and (3) the interpretation of the groups of symbols that form sentences and paragraphs.

In the act of perception the reader sees the words and phrases of the printed page, or to describe the process from another point of view, the printed symbols are given an opportunity to function as visual stimuli in an appropriate order. The child who has not learned to read may see some or possibly all of the words when he looks at a printed page but his perception is not that of a reader. The recognition involves a response to the perceived symbol. In silent reading this response probably includes an inaudible or sub-vocal pronunciation of the word, but a more significant phase is the mental recognition which in the case of familiar words includes the association of some degree of meaning with the visual stimuli. The most significant phase of the interpretation is the association of appropriate meaning with the groups of words that form sentences and paragraphs rather than with the separate words. Obviously meanings must be associated with separate words and phrases, but this response does not mark the end of the process in effective silent reading. The elements of meaning stimulated in the reader's mind by the printed symbols must be evaluated and those that are appropriate must be synthesized to form the meaning of the sentences and paragraphs.

These phases of the silent reading process are not to be regarded as discrete and independent steps taken always in the order mentioned. In the case of a proficient reader, at least, the three phases are intermeshed and practically simultaneous. As the fluent reader proceeds through the sentence or the paragraph, the meanings acquired up to a given point lead him to anticipate later meanings. They assist him in perceiving and recognizing the symbols encountered further on in the passage and may even lead him, if he has anticipated incorrectly, to "see" symbols that are not on the page at all. It is also true that the meanings gained from some of the words frequently enable the reader to recognize words that he has not previously encountered in printed form and to attach meanings to words that are altogether new to him.

**Oral versus silent reading.**—Silent reading is essentially the process of comprehending the printed page. Oral reading is essentially the utterance, with correct pronunciation and proper expression, of the sounds corresponding to the printed symbols on the page. Although there is undoubtedly a relationship between these types of reading, they are nevertheless distinctly different processes. Oral reading is not simply silent reading plus articulation. An individual may be relatively proficient in one of these processes and relatively incompetent in the other. One who has not been trained in oral reading may exhibit marked deficiencies in pronunciation, emphasis, inflection, rhythm, and so on, and yet grasp the writer's thought readily when reading silently. On the other hand, the person who has been over-trained in oral reading to the neglect of instruction in silent reading may perform very creditably in the former without the ability to understand adequately what the writer has said.

The preceding statements are not intended to imply that proficiency in oral reading is not desirable nor that oral reading has no proper place in the school. The ability to read well orally is frequently serviceable and should be regarded as one of the objectives of instruction in reading. Furthermore, the pupil at the beginning of the study of reading has a speaking vocabulary of many hundreds of words and the early stages of learning to read should consist in associating at least some of these familiar words with the corresponding printed symbols. This speaking vocabulary can be capitalized most effectively through oral reading. Most of the reading one does, however, in school and in life, is silent rather than oral, and it is important that one become highly proficient in the silent comprehension of printed material. Silent reading is a much more rapid process than oral reading, since the mature reader is able to recognize and interpret the printed symbols much faster than the vocal apparatus can function in pronouncing the corresponding words. If instruction in oral reading is continued too long to the neglect of training in silent reading, the result is likely to be that the learner acquires reading habits that will interfere with efficiency in silent reading.[1]

**Eye-movements in reading.**—A very important phase of the perception of printed material is the movement of the eyes during this process. Printed words are merely groups of black marks on white paper. The marks, called letters, are conventional in form and although each has distinguishing characteristics, some of the differences in form are relatively slight. Some of the groups of letters that we call words differ only slightly. For example, t-h-o-u-g-h differs from t-h-r-o-u-g-h only by one letter.

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[1] The remainder of this section is devoted to silent reading. The reader who is interested in the psychology of oral reading should consult BUSWELL, G. T.—"An Experimental Study of the Eye-voice Span in Reading." *Supplementary Educational Monographs*, No. 17. Chicago: University of Chicago, 1920, 106 pp.

The words b-i-t-t-e-r and b-e-t-t-e-r also are very similar. In fluent silent reading printed words are seen or perceived at the rate of 250 or more per minute. Obviously this achievement involves skillful movements of the eyes along the printed lines in order to see the words and phrases.

By means of somewhat elaborate apparatus it is possible to obtain photographic records of the eye-movements made in reading.[1] Investigation has revealed that the reader's eyes do not move along a printed line in a continuous sweep, but rather in a series of short, rapid movements each of which is followed by a brief pause, or period of fixation. It is only during the pauses that the symbols are seen.

There are three characteristics of eye-movements that are very significant as indicators of the degree of proficiency attained by the reader: (1) the number of pauses, or fixations, made in each line; (2) the length of each pause; and (3) the number of backward, or regressive, movements made in each line. The differences between the eye-movements of an unskilled reader and a skilled reader are strikingly shown by Figures 39 and 40.[2] The former presents a photographic record of the eye-movements of a pupil in Grade IA, and the latter a record of a

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[1] For a description of this apparatus see GRAY, C. T.—"Types of Reading Ability as Exhibited Through Tests and Laboratory Experiments," *Supplementary Educational Monographs*, No. 5. Chicago: University of Chicago, 1917, pp. 83–91.

[2] These figures are taken from BUSWELL, G. T.—"Fundamental Reading Habits: A Study of Their Development," *Supplementary Educational Monographs*, No. 21. Chicago: University of Chicago, 1922, pp. 2–3. The reader will be richly repaid for reading the entire monograph, as well as other monographs of the series dealing with various aspects of the subject of reading. The Chicago reading studies afford an excellent illustration of the valuable service which the psychological laboratory can render to education.

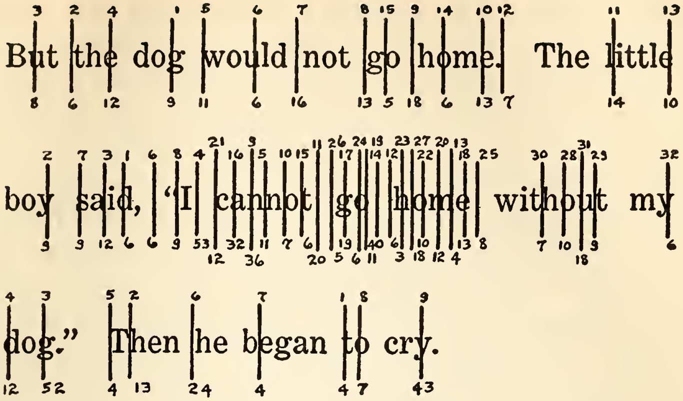
But the dog would not go home. The little
boy said, "I cannot go home without my
dog." Then he began to cry.

FIGURE 39. PHOTOGRAPHIC RECORD OF EYE-MOVEMENTS OF A POOR READER. (After Buswell.)

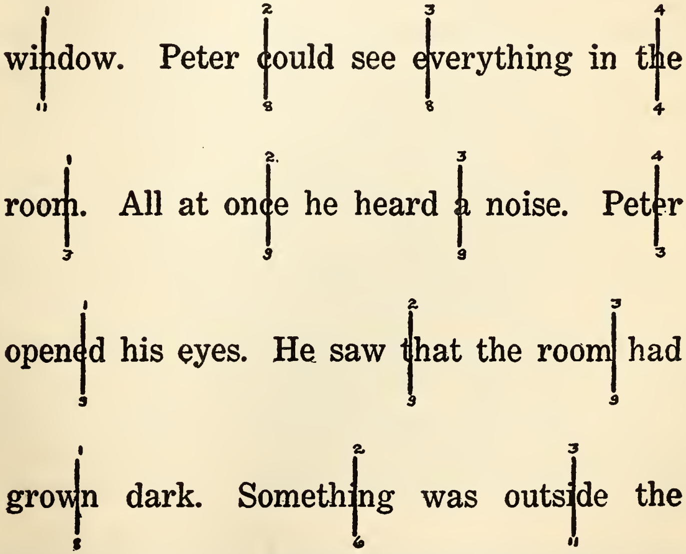
window. Peter could see everything in the
room. All at once he heard a noise. Peter
opened his eyes. He saw that the room had
grown dark. Something was outside the

FIGURE 40. PHOTOGRAPHIC RECORD OF EYE-MOVEMENTS OF A GOOD READER. (After Buswell.)

college senior. The reading in both cases was silent reading. Each vertical line represents a fixation pause. The numbers at the tops of the lines indicate the sequence of the pauses, and the numbers at the bottoms show the lengths of the pauses in twenty-fifths of a second.

Examination of Figure 39 shows that the reading of the first-grade pupil is characterized by many fixation pauses, some of which are relatively long, and by regressive eye-movements. This reader did not fix his eyes on each letter separately but it is obvious that he is grossly lacking in ability to recognize words rapidly. On the other hand, the college senior fixed his eyes at only three or four points in each line. Hence it is apparent that the development of proficiency in reading is attended by a marked decrease in the number of fixations and of regressive movements, and by some reduction in the length of fixation pauses.

These changes, however, should be regarded as evidences or effects of improvement in ability to read rather than as causes of it. Records of the eye-movements of an individual while reading different passages show that the eye-movements vary as the difficulty and type of reading material are changed. An individual whose eye-movements are "good" when reading typical fiction is likely to exhibit inefficient eye-movements when he attempts to read blank verse or a typical textbook in geography, rhetoric, or algebra.[1] This means that the presence of new words, especially long ones, long sentences, and other characteristics that make the comprehension of sentences and paragraphs difficult will affect adversely a reader's eye-movements. Hence, training in reading should consist not so much of attempting directly to modify the character of the eye-movements, in order that efficient reading may follow, as of seeking to remove the reading difficulties that result in an excessive number of fixations and regressions and in undue length of pauses.

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[1] Judd, C. H., and Buswell, G. T.—"Silent Reading: A Study of the Various Types," *Supplementary Educational Monographs*, No. 23. Chicago: University of Chicago, 1922, Chapter II.

Buswell[1] reports that the reduction in the number of fixations and of regressive movements and in the length of the pauses is most rapid in the first four grades of the elementary school. From the fifth grade on there is relatively little improvement in these respects. This is due, Buswell thinks, to the changed conditions with respect to reading after the fourth grade. The limit of improvement has not been reached at this point, but there is henceforth considerably less emphasis on reading. Furthermore, the changed character and purpose of reading as the formal subjects are more and more replaced by content subjects interfere with the development of ability to read and hence of good eye-movements.

**The span of recognition.**—In commenting on Figure 40 attention was called to the fact that a good reader fixes his eyes at only a few points in each line. The amount of printed material recognized during such a period is called the "span of recognition." Laboratory studies have revealed that a reader may perceive several letters and even short sentences[2] when material is exposed for a small fraction of a second, and hence during only one fixation. The number of letters perceived during a single fixation represents the span of perception. It appears to be only slightly affected by training and then only when the subject is young. A person's span of perception tends to place an upper limit upon the development of his span of recognition in reading, but studies show that "the span of perception is usually much greater than the size of the unit recognized in reading."[1] Hence usually the span of recognition may be materially increased by appropriate training.

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[1] Buswell, *op. cit.*, Chapter II.

[2] For a more extended account of this topic see Gray, C. T.—*Deficiencies in Reading Ability*. Boston: D. C. Heath and Company, 1922, pp. 83f.

**Learning to recognize words and groups of words.**—Since a printed word consists of a group of letters, it may seem that learning to recognize the letters of the alphabet should constitute a preliminary step in learning to recognize words and groups of words. For a long time this was assumed to be true. From the time of the Greeks and Romans down to a few generations ago, the alphabet method was in common use in instructing the beginner in reading. The pupil first learned to repeat the names of the letters and to recognize each letter at sight. Then he was drilled upon numerous two-letter combinations, both meaningful and meaningless, such as ba, be, bi, bo, bu, by, ca, ce, ci, and so on. Next he learned to read phrases containing words of two letters each. Then he was introduced to three-letter words, and thus the process was continued until the pupil learned to recognize and pronounce long and difficult words.

Undoubtedly the alphabet method was uneconomical and irksome. If they were held to the monotonous task long enough, children finally learned to read, at least after a fashion; but they neither learned so quickly nor read so well as do children taught by present-day methods.

The reasons for the inefficiency of the alphabet method are not far to seek. In the first place, knowing the name of a letter is a very different thing from recognizing its sound value in a word. The pupil may, for example, know the names of the letters "c," "o," and "w," but merely this achievement will not enable him to pronounce the word "cow." It is true that, if he is drilled long enough on the letters and various combinations of them, he may at last come to assign sound values to the letters and combinations, and thus become able to recognize words whose written forms are new to him. But in such case it is probably correct to say that he does so in spite of the fact that he had "learned his ABC's" rather than because of it.

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[1] Gray, W. S.—"Summary of Investigations Relating to Reading," *Supplementary Educational Monographs*, No. 28. Chicago: University of Chicago, 1925, pp. 78–79.

In the second place, the alphabet method involved the erroneous assumption that the letter is the unit of perception in reading. Although words are made up of letters, a skillful reader does not look at each letter in recognizing a word. The truth of this statement has been demonstrated by scientific investigation. It is apparent when a person without training in such work attempts to read printer's proof for the purpose of locating typographical errors. Even though he may read carefully, he will not be efficient in detecting misspellings, broken type, and the like. He is likely to fail in detecting all missing words. The explanation of his unsatisfactory performance as a proof-reader is that he does not look at each letter, and perhaps not even at each word.

In the third place, the alphabet method was unattractive to the learner and failed to enlist his interest and effort in anything like the degree to which present-day methods do. There was, to the child, little or no meaning in the early stages of the process of learning to read. The meaningless, monotonous drill resulted in a failure, on the part of the pupil, to acquire a conception of reading as a process of thought-getting. Reading tended to become and to remain too much a mechanical process of recognizing and pronouncing words without any great concern as to the thought expressed by them.

During recent years the alphabet method has been discarded in favor of the word method. According to this method the pupil begins by learning to recognize words instead of letters. The psychological soundness of this method should be apparent. Before the child begins the study of reading he has acquired a speaking vocabulary, and learning to recognize words is merely the type of sensori-motor learning in which the child connects a response he already is able to make with a new stimulus.[1] For example, the word "boy," which he has learned to use in conversation, is presented on the blackboard or on a chart and he soon learns to associate the oral response of pronouncing the word with the stimulus represented by the combination of letters that form the printed word. Experience in teaching pupils has revealed that they learn to recognize words as readily as they learn to recognize letters, and the method is far more interesting to them.

Some teachers of reading have contended that the sentence, rather than the word, is the proper unit to employ at the beginning of reading. They point out that, since the sentence expresses a complete thought, it is more meaningful than the word, and hence causes the pupil from the very beginning of the process to read with expression and to look upon reading as a process of thought-getting. This method, however, cannot be continued indefinitely without attention to words, and consequently has a limited usefulness. The pupil must become able to recognize separate words, since he obviously cannot be taught to recognize all the sentences he is to read.

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[1] See page 152.

Just as the sentence method must soon be supplemented by the study of words, so the word method soon necessitates the analysis of words into their component sounds. If the pupil is to acquire the power of independent mastery of words whose printed form is unfamiliar to him, he must become able to assign the proper sound values to the elements of the words.

The ability to analyze words phonetically may be acquired incidentally or through explicit attention to, and instruction in, the process. Without explicit training in phonetics, most children will acquire the ability to substitute sound values for letters in an unfamiliar word only after a relatively long period and some will never acquire it. Hence, it seems desirable to begin early to give instruction in phonics as one aspect of the teaching of reading. It has been recommended, and doubtless rightly, that the instruction in phonics be given during a different period from that devoted to the reading lesson proper, since in the latter the emphasis should be placed on reading for the purpose of getting the thought and expressing it properly.

**Pronunciation as a means of recognizing difficult words.**—In fluent oral reading the pronunciation lags behind the perception of the words. A large eye-voice span is a characteristic of good readers.[1] The association of meaning with the words appears to occur near the point of fixation of the eyes rather than near the point of pronunciation. Experimental evidence shows that when a good reader encounters a difficult word, his eye-voice span is greatly reduced, and the association of meaning with the words appears to shift to the point of pronunciation. This probably means that pronouncing a difficult word is used as means of recognizing it.[1] In other words, the reader reverts to the primitive methods employed when he began to learn to read.[2]

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[1] It appears, however, that size of the eye-voice span does not determine the quality of the reading. Buswell states: "It would appear that both are effects, and that the causal element is the existence of a general attention span wide enough to hold a large number of words or reading elements in the mind at one time. The preceding evidence shows that a poor, immature reader can hold only a few letters or words in the focus of attention, while more mature readers are the ones who have a wide attention span. Progress in reading would therefore be a matter of the development of the span of attention to such a degree

**The interpretation of sentences and paragraphs.**—In silent reading the recognition of words and phrases is followed by associating meanings with the symbols recognized. If the word recognized is one for which the reader has a meaning, this meaning is associated with it at the moment of recognition. If it is an unfamiliar word, he may acquire a meaning from the context. If an adequate meaning cannot be obtained from the context, then a dictionary or some other reference book may be consulted for the meaning.

The process of silent reading is not completed, however, with the act of associating meanings with the words and phrases seen. These elements of knowledge must be synthesized into the meaning of sentences and paragraphs. Thorndike has described this phase of silent reading as follows: "Understanding a paragraph is like solving a problem in mathematics. It consists in selecting the

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that it would be possible for the eye to keep a considerable distance ahead of the voice and thus provide a wide margin for the interpretation of meaning."

Buswell, G. T.—"An Experimental Study of the Eye-Voice Span in Reading," *Supplementary Educational Monographs*, No. 17. Chicago: University of Chicago, 1920, pp. 101–02.

[1] *Ibid.*, p. 102.

[2] See page 446.

right elements of the situation and putting them together in the right relation and also with the right amount of weight or influence or force for each. The mind is assailed, as it were, by every word in the paragraph. It must select, repress, soften, emphasize, correlate and organize, all under the influence of the right mental set or purpose or demand."[1]

This description of the comprehension of sentences and paragraphs makes clear its complexity and difficulty. In solving a problem in mathematics the pupil is expected to take some time for reflection. In fluent reading he comprehends several hundred words per minute. Each sentence presents a "problem" to be solved, and in a typical textbook some of them will probably be difficult. Each school subject has a relatively large technical vocabulary of its own. Hence, it is not surprising that many high-school pupils have not become good readers.[2]

**Relation of reading to experiencing.**—Obviously a pupil is greatly handicapped in interpreting sentences and paragraphs if his stock of meanings is limited in the field of the material that he is attempting to read. Hence a pupil's ability to read is dependent upon the status of his learning. A fundamental cause of poor comprehension may be a lack of appropriate perceptual experiences.[3]

**Illustrations of typical comprehension.**—Irion's study, to which reference was made in the preceding chapter, affords excellent illustrations of inadequate comprehension in silent reading. One hundred seventy representative ninth-grade pupils were given a group of five comprehension tests on Byron's *The Destruction of Sennacherib* which Irion found to be among literary selections "approved by eminently successful teachers of English as being fit for ninth-grade use." The first stanza of this poem is:

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[1] THORNDIKE, E. L.—"Reading as Reasoning: A Study of Mistakes in Paragraph Reading," *Journal of Educational Psychology*, 8:323–32, June, 1917. Also, "The Understanding of Sentences: A Study of Errors in Reading," *Elementary School Journal*, 18:98–114, October, 1917.

[2] See page 420.

[3] The reader will find it helpful to review pages 205–06.

> The Assyrian came down like the wolf on the fold;
> And his cohorts were gleaming in purple and gold;
> And the sheen of their spears was like stars on the sea,
> When the blue wave rolls nightly on deep Galilee.

By substituting in the original version the answers given to the test questions, the result in the case of one pupil whose total comprehension score was considerably higher than the average of the group was as follows:

> The Assyrian, an Aryan, came down upon the city of Ashur like a wolf on the fold; and his garments were gleaming in purple and gold. The points of (their) spears was like stars on the sea, when the tide comes in by night. He had a highly decorated but not very efficient army and undertook the invasion to humble the Chaldeans.[1]

Since tests of the multiple-choice form were used, the answers were suggested by the tests. Irion thinks that, if allowance is made for this condition, this pupil's comprehension of the stanza would take some such form as:

> The Assyrian, that is somebody, came down like a wolf on the fold, and something he had on was gleaming in purple and gold, and the something of their spears was like stars on the sea when something happens to the waves by night.[2]

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[1] Irion, T. W. H.—"Comprehension Difficulties of Ninth Grade Students in the Study of Literature," *Teachers College, Columbia University Contributions to Education*, No. 189. New York: Bureau of Publications, Teachers College, Columbia University, 1925, p. 53.

[2] *Ibid.*, p. 54.

The foregoing interpretation, it should be remembered, was made by a superior pupil. The following version indicates the degree of comprehension on the part of a pupil whose total comprehension score was the top of the lowest fourth of the group of 170 pupils:

> The Assyrians came like wolves by night, crossing the rolling waves of the sea of Galilee. And his weapons were gleaming like purple and gold; and the sharpness of their spears was like the sea of stars seen by Galileo.[1]

One may properly question whether children should spend their time in studying literary selections that they succeed in comprehending only to the degree evidenced in the illustrations just given. We cannot here inquire exhaustively into the reasons for the failure on the part of the two pupils mentioned to interpret the poem more adequately. Although lack of knowledge of some of the words and an insufficient background of essential information doubtless were factors, it is also likely that inability to carry out effectively the activities designated by Thorndike in the quotation above was a very influential cause of failure to comprehend the selection.

**Types of reading.**—The closing words of the quotation from Thorndike suggest the large part that the pupil's purpose or attitude plays in determining the nature of his mental activity when he is reading. Judd and Buswell[2] have demonstrated the same fact very clearly and convincingly. Their photographic records of eye-movements, which are symptomatic of the general character of the activity in progress in the mind of the reader, show that the pupil's response is a very different thing according as he reads for different purposes such as getting a general notion of what he reads, understanding clearly what he reads, answering questions about what he reads, and reproducing verbatim what he reads.

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[1] Irion, *op. cit.*, p. 54.

[2] Judd, C. H., and Buswell, G. T.—"Silent Reading: A Study of the Various Types," *Supplementary Educational Monographs*, No. 23. Chicago: University of Chicago, 1922. 160 pp.

It is likely that there are as many different types of reading as there are different purposes in view in engaging in this activity. Without attempting an exhaustive list of possible purposes, it may be helpful to recognize the following as among the more common and the more important ones:

1. Reading to understand.
2. Reading to remember
3. Searching for information
4. Reading to criticize the text
5. Supplementing the text
6. Analyzing the text
7. Reading for enjoyment

These purposes are not, of course, mutually exclusive. "Reading to criticize the text" involves "reading to understand," but the total process is different. Similarly "supplementing the text" involves "reading to understand," but there is also reflection in which the reader makes an effort to think of illustrations of the statements in the text, to recall other discussions of the topic, to elaborate the author's treatment, or to consider the application of what is being read.[1]

**Relation between rate and comprehension in silent reading.**—With reference to a given text, a pupil's achievement in silent reading may be described in terms of his rate of reading and the quality of his comprehension. For example, a pupil may read a given passage at the rate of 275 words per minute and comprehend 70 per cent of the ideas in the passage. It has often been supposed that rapid reading is detrimental to thought-getting and that one should proceed slowly and deliberately in order to understand the material that is being read. This appears, on the whole, to be an erroneous belief.[1] While there are individual differences in this respect as in all others, some slow readers grasping and retaining the thought well and some fast readers failing to do so, yet in general the faster readers excel the slower ones in comprehension of what is read. It is true that slow, careful reading of difficult material, at least, yields more ideas per page than does rapid reading; but on the other hand, rapid reading is likely to yield a greater number of ideas per unit of time spent.

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[1] For a more comprehensive discussion of these types and for suggestions of procedures that should be helpful in engendering the various purposes listed above, see MONROE, WALTER S.—*Directing Learning in the High School.* Garden City, New York: Doubleday, Doran and Company, Inc., 1927, pp. 195–202.

The superiority of the fast reader is not hard to understand. He is a fast reader because he is a superior one. That is to say, the rapid reader has a relatively wide recognition span and recognizes the words and phrases quickly. Hence, he passes over the material at a fast rate without confusion or difficulty. This the slow reader cannot do, because of his limited recognition span and his inferior ability in recognizing the words. Again, it may be assumed that the number of ideas gained from reading a given amount of material depends in part upon the degree of concentration during the reading. Rapid reading tends to be characterized by more intense activity than does slow reading, and thus brings better returns.

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[1] For a summary of studies of the relation between rate and comprehension, see Gray, W. S.—"Summary of Investigations Relating to Reading," *Supplementary Educational Monographs*, No. 28. Chicago: University of Chicago, 1925, pp. 124f.

Doubtless most people read at a rate which is considerably slower than that which they could attain with a limited amount of practice and without any loss in comprehension. Children should be encouraged and taught to read as rapidly as they can, consistently with grasping the thought of the material. This training, it may be added, need not and should not be confined to the reading lesson only, but may be extended to other subjects involving extensive reading.

**Reading as a learning activity.**—A large portion of a pupil's learning beyond the first six grades is accomplished through the study of textbooks. Several of the types of learning activities listed in Chapter VI involve reading.[1] Hence the pupil not only learns to read but he also employs reading as a tool of learning. The preceding discussion has been restricted to the process of reading. The use of reading as a tool of learning belongs in the field of methods.

**The measurement of achievement in silent reading.**—The product of the reading process is subjective and hence not observable by another person. This requires that the reading of a selection be supplemented by some performance that is observable. In order that this observable performance may be the index of a pupil's comprehension of the material read, it must depend upon his comprehension or be related to it in some way. The most common type of test exercise consists of a short paragraph to be read and one or more questions based on it. "New-type" questions are usually used so that very little of the pupil's time is consumed in giving his answers. The following quotation from the Monroe Standardized Silent Reading Test illustrates this type of exercise:

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[1] See pages 200–1.

> Heralds on swift horses transmitted the message from hand to hand, village repeated it to village, the sea to the backwoods, the plains to the highlands, till it had been borne north, and south, and east and west, throughout the land.
>
> Draw a line under the word which best describes this scene.
>
> excitement    lassitude    activity    fighting    sluggishness
>
> The Indian men, when old, are counselors; for their government is by counsel of the sages; there is no force; no officers compel obedience or inflict punishment. Hence they generally study oratory in order to be good speakers.
>
> By what means did the Indians enforce their laws?
>
> policemen    influence    navy    soldiers    love

The length of the passage to be read varies from two or three lines to a page or more. The number of questions also varies. Silent-reading tests usually include a number of separate exercises, but a few consist of a single selection followed by a list of questions on it. When a test consists of several exercises, they may be approximately equivalent in difficulty or they may range from very easy to very difficult. When the latter condition prevails, the exercises are usually arranged in order of increasing difficulty. The test may be timed to secure a measure of both rate of reading and degree of comprehension. When the test is scaled, that is, consists of exercises arranged in order of increasing difficulty, the time allowed is usually sufficient for a pupil to attempt practically all of the exercises he is able to do correctly. In such a case the resulting score is an index of difficulty of the material he is able to read satisfactorily.[1]

The measurement of achievement in silent reading differs in a significant respect from the measurement of achievement in handwriting. In the latter case the act of writing produces an observable record. In silent reading the pupil's comprehension cannot be observed and cannot be tested directly. This situation increases the possibility that the resulting scores may be lacking in validity.[2] Furthermore, if several types of reading are recognized, it is probable that the type of test described above measures ability to find the information needed for answering certain questions and does not yield satisfactory measures of ability to engage in other types of reading. Silent reading tests are widely used and they are generally recognized as useful instruments, but the preceding discussion of the reading process makes apparent certain limitations, which a teacher should keep in mind.

**The relation of ability to read to general intelligence.**—On page 440 it was pointed out that there was very little relation between general intelligence and ability in handwriting. The opposite condition prevails in the case of reading. Achievement in silent reading is a rough index of general intelligence. This is indicated by the prominence of verbal exercises in intelligence tests.[3] Reports of coefficients of correlation between scores yielded by silent reading tests and those yielded by general intelligence tests have varied widely. A few of the coefficients have been between .80 and .90 but the majority are considerably lower. The average is probably between .50 and .60.

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[1] A reader who is interested in reading tests should consult a text on educational measurement, such as MONROE, WALTER S., DEVOSS, J. C., and KELLY, F. J.—*Educational Tests and Measurements* (Revised and Enlarged Edition). Boston: Houghton Mifflin Company, 1924, Chapter III.

[2] See page 328.

[3] See page 269.

**Problem cases in teaching reading.**—Under ordinary conditions of instruction many children fail to make satisfactory progress in learning to read. The causes of unsatisfactory progress are numerous, and a comprehensive consideration of them, together with appropriate remedial measures in each case, lies outside the scope of the present volume.[1] It seems desirable, however, to mention here some of the more common causes of failure in reading and to comment briefly on each.

1. Obviously the child with visual or auditory defects is handicapped in learning to read.[2] In order to make proper progress in reading, the learner must be able to see the printed symbols and hear the oral sounds accurately and without too great effort. There are also some children who are defective in auditory memory, although the auditory apparatus functions normally. These children may hear the sounds correctly, but they are unable to remember the sounds after hearing them. It need hardly be said that, if a pupil manifests unusual difficulty with reading, the teacher should at once determine whether visual or auditory defects are present.

2. Another cause of failure in reading is the defect known as congenital word blindness, or dyslexia. Concerning this defect Gray[3] says: "It refers to inability to

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[1] The best references on the topic of special deficiencies in reading and remedial training are Gray, W. S.—"Remedial Cases in Reading: Their Diagnosis and Treatment," *Supplementary Educational Monographs*, No. 22. Chicago: University of Chicago, 1922. 208 pp. Gates, A. I.—*The Improvement of Reading*. New York: The Macmillan Company, 1929. 440 pp.

[2] Evidence will be presented in a later chapter to show that visual and auditory defects are by no means uncommon. See pages 569f.

[3] Gray, W. S.—*op. cit.*, pp. 13–14.

understand and interpret symbols rather than to inability to see them and is attributed to imperfections or lack of development of those areas of the brain which normally serve as centers for recording images or memories of printed or written symbols. The fact that cases of dyslexia have been found in several generations of the same family suggests that it is a hereditary trait. . . . There are wide differences in the character and severity of cases of dyslexia." Persons afflicted with some degree of dyslexia may make some progress in reading if proper instructional procedures are employed, but in the more severe cases this defect renders all efforts at reading fruitless.

3. There are some children, of course, whose level of mentality is so low that they learn to read with difficulty, if at all. The number, however, who cannot learn to read easy material, at least, if suitable instruction is given is relatively small. There are frequent cases of pupils with inferior learning capacity who fail to make much progress in reading until they are segregated and appropriate material and methods of instruction are employed.

4. It was pointed out earlier in the chapter that inefficient eye-movements are an evidence of a lack of proficiency in reading. It is sometimes true that a pupil acquires improper habits of eye-movement which interfere with progress in reading. In such cases, remedial exercises designed to cultivate proper eye-movement habits may lead to marked improvement in the reading process. Measures should be taken to train the pupil to avoid regressive movements, to take in a greater range of symbols at each fixation, thus reducing the number of pauses per line, and to make properly the return sweep to the beginning of each successive line.

5. A rather common deficiency on the part of poor readers is the inability to recognize words independently. They lack the power to analyze words into their component sounds and to synthesize these sounds into words as wholes. The remedy, of course, is to be found in instruction in word analysis and phonetics.

6. A poor quality of oral reading, as well as a slow rate of silent reading, is often the result of a narrow span of recognition. That is to say, the pupil is able to recognize only a very limited portion of the line at each fixation, and hence requires an excessive number of pauses in each line. In many cases the span of recognition may be widened by means of drills with flash cards, the length of the phrases on the cards being gradually increased as the training proceeds. Procedures that result in at least short periods of rapid silent reading may also be beneficial.

7. Undoubtedly a frequent cause of difficulty in reading is the pupil's limited vocabulary. Some children come from homes in which little or no English is spoken and many others from English-speaking families that employ a relatively narrow range of vocabulary. In either case the pupil meets many words in reading for which he has no adequate meanings even if he is able to pronounce them. In such cases, obviously, it is essential that special attention be given to vocabulary development and to the comprehension phase of reading.

8. The last cause of unsatisfactory progress in reading that we shall mention here is a lack of interest in reading, which may be the result of various conditions. Frequently a lack of interest is due to poorly chosen material which the pupil is required to read and which he does not enjoy or cannot understand. It may also be due to discouragement and lack of confidence because of difficulties

which the pupil has experienced in reading. In many cases, no doubt, a lack of interest is the result of overemphasis on the mechanics of reading to the neglect of attention to the thought of the material, the final effect on the pupil being that he fails to acquire a proper conception of reading as a thought-getting process. Whatever the reason for the pupil's unfavorable attitude toward reading may be, he is not likely to make satisfactory progress in reading until his attitude is changed.

## III. Arithmetic

**The general nature of arithmetic.**—Arithmetic is commonly thought of as consisting essentially of calculating and solving verbal problems, but a psychological analysis reveals a more complex subject. In the first place the idea of number is an abstraction. A group of objects such as apples or blocks has certain sensory qualities. An apple has its characteristic color, shape, odor, and taste. These qualities stimulate certain sense organs with the result that the perception of an apple is relatively simple. Counting a group of six apples is a very different process. The sensory qualities are disregarded and the objects are paired with the number names—one, two, three, four, five, and six. The conclusion that there are six apples in the group is the product of a mental process which is relatively difficult for the child who is learning the idea of number. It is much more difficult than forming an association between the symbol "boy" and the oral word. Acquisition of the idea of number must be followed by associating the various numbers with the conventional symbols of our number system so that numbers can be written and read. Finally, the child must learn conventional signs such as + ÷ $23\overline{)1852}$ as prerequisites for proficiency in calculating.

Arithmetic is not a simple, easy subject, and it is not surprising that many pupils fail to do satisfactory work in it. In the first place, our number system is highly abstract. Possibly this fact in itself explains why it, and especially the Arabic system of writing numbers, was developed relatively late in human history. Roman numerals were generally used in Europe as late as the sixteenth century. Even to-day semi-civilized tribes resort to many devices other than numbers in keeping records. Judd[1] has pointed out that the "Apache Indians of Arizona keep a record of their ponies by carrying a little sack filled with pebbles, the number of which corresponds to the number of ponies in their drove." Other tribes are reported to keep tally by tying knots in a piece of string. Only peoples of advanced intelligence successfully handle arithmetical calculation—that highly complex game played with the ten symbols, 1, 2, 3, 4, 5, 6, 7, 8, 9, 0. In the second place, solving verbal problems requires that the child learn a large number of facts from our social and business life and a number of qualitative relationships. A large portion of the vocabulary employed in stating problems is unique and the child must learn to speak and read the language of arithmetic.

**Learning the number concept through counting.**—The child acquires the concept of number primarily from his experience in counting objects. He may learn the number names—one, two, three, four, etc.—as mere abstractions and be able to repeat them in correct serial order upon request; but in counting a group of objects he must pair off the several objects with the appropriate number symbols. If this pairing off (counting) process is completed when the number symbols one, two, three, and four have been used, the number four represents a characteristic of the group. In the same way counting other groups of objects leads to the concept of other number symbols.

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[1] Judd, C. H.—"Psychological Analysis of the Fundamentals of Arithmetic," *Supplementary Educational Monographs*, No. 32. Chicago: University of Chicago, 1927, p. 7.

From the activity of counting, the child learns the meaning of the smaller numbers and develops the general idea of number and of a number series beginning with one, two, three, four, and extending indefinitely.

**Learning to read and write numbers.**—Learning to read and write numbers is relatively easy. When the child has learned the number names, learning to read numbers expressed in the Arabic notation such as 7, 13, or 24, is comparable with learning to read the printed words. As soon as he becomes acquainted with the decimal plan of our number system and the place value of a digit he is equipped to read any number correctly the first time he sees it.

Learning to write numbers involves learning to make the movements required to form each of the digits and then establishing associations between these movements and oral or visual stimuli so that the required digits will be written when a number is heard or seen. This process is similar to learning to write, but if the child has already learned to hold a pen and to form letters, it is relatively easy.

**Learning the fundamental combinations.**—The number fact, $3 + 4 = 7$, may be arrived at by placing a group of three objects with a group of four objects and counting the total collection. The number fact, $8 - 5 = 3$, may be arrived at by counting and removing five of the objects from a group of eight and then counting the remainder. By somewhat more complicated procedures the fundamental combinations of multiplication and division may be "discovered" by counting objects. Some combinations may be developed from those previously learned. For example, $6 \times 3 = 18$ may be developed by addition.

Counting and other procedures provide a basis for learning the meaning of the operations of addition, subtraction, multiplication, and division as well as the particular combinations dealt with. The learning of the meaning of these operations is important, and when once they are understood as represented in the fundamental combinations, the economical way is for the child to accept the fundamental combinations from the teacher or the textbook and memorize them by means of attentive repetitions. The effectiveness of this procedure, however, is dependent upon the child's understanding what the combinations mean. If $17-8 = 9$, or $36 \div 9 = 4$ are only meaningless groups of symbols to him, he is not ready to memorize these combinations, and should be required to continue counting or whatever other procedure will afford a basis for understanding the meaning of the combinations to be learned.

The principle that drill alone is not adequate for learning the fundamental combinations has been emphasized by a recent writer.[1] Although drill by means of flash cards and other devices may appear to result in a knowledge of the combinations, investigation frequently reveals that the pupil does not know them in an effective way. He soon forgets some of them and lacks resourcefulness in developing them from his experience. It is probable that for most pupils drill on the fundamental combinations is not an appropriate learning activity in the primary grades. Certainly it should be employed sparingly until it is apparent that the pupils understand the combinations.

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[1] Brownell, W. A.—"The Development of Children's Number Ideas in the Primary Grades," *Supplementary Educational Monographs*, No. 35. Chicago: University of Chicago, 1928, pp. 159f.

**The fundamental combinations to be learned.**—Until recently it was generally assumed that as a prerequisite for becoming proficient in arithmetical calculation it was necessary for a pupil to learn the tables in addition, subtraction, multiplication, and division only through the 9's; some authorities omitted the zero combinations; it was believed that two combinations involving the same numbers as $6 + 8 = 14$ and $8 + 6 = 14$, or $7 \times 3 = 21$ and $3 \times 7 = 21$ were essentially the same and hence should be treated as single combinations. Studies of the achievements of pupils in this field have revealed that the zero combinations are important and that the teacher is not justified in considering two combinations such as $7 \times 3 = 21$ and $3 \times 7 = 21$ as essentially the same. Although knowing one facilitates the learning of the other, it is necessary to provide drill on each. Furthermore, investigation has revealed that the tables through the 9's do not include all of the combinations to be learned. A pupil may know $9 + 6 = 15$ but not know $19 + 6 = 25$. Consequently it is necessary for the pupil to form two specific habits in learning these combinations. Likewise, $26 + 7 = 33$, $36 + 7 = 43$, and so on, form the basis of still other specific habits. Hence, the number of specific habits needed in addition is much larger than is often recognized.

One investigator,[1] after careful inquiry, has concluded that there are 412 addition combinations which a child "is almost sure to need after he leaves school." This means that if a child fails to learn any one of these 412 combinations there will be a corresponding "gap" in his ability to add integers. The number of fundamental combinations which it is necessary to master in subtraction, multiplication, and division is in each case smaller than in the case of addition, but the number is much larger than has been commonly recognized.

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[1] Osborn, W. J.—*Corrective Arithmetic.* Boston: Houghton Mifflin Company, 1924, p. 21.

The specific habits represented by the fundamental combinations are by no means unrelated, and the formation of some of them considerably facilitates the acquisition of others. Thus, knowing that 9 + 6 = 15 facilitates the learning of 19 + 6 = 25. It should not be forgotten, however, that the objective to be attained is not the ability to repeat the combinations in a fixed order. In adding a column of figures the order of the combinations required is determined by the arrangement of the figures. Similarly in the other operations the order is determined by the form of the example. Addition is encountered in multiplication examples involving carrying. For example, in multiplying 469 by 8, 7 must be added to 48 and 5 to 32. Long division involves addition, subtraction, and multiplication. Consequently proficiency in arithmetical calculation requires that the fundamental combinations be learned so well that the correct response is given promptly whenever the combination is encountered.

**Avoidance of incorrect associations important.**—In the acquisition of motor skill, there is, in general, a necessity for a more or less prolonged period of trial-and-error learning.[1] The desired response cannot be made at the first attempt; on the contrary, it is the result of numerous efforts to perform the act in the proper manner. In arithmetic, however, the situation is different, since the correct response can be made from the beginning. There is nothing inherent in the nature of the response itself that makes the correct response impossible without practice. For example, it is theoretically possible to associate 16 with 9 + 7 the first time this combination is encountered and follow this initial connection by such a distribution of later repetitions of the response, that 9 + 7 will never become associated with any other number than 16. Errors in arithmetic should be controlled by preventing incorrect associations rather than by allowing these associations to be made and then attempting to destroy them.

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[1] See pages 153f.

**The amount and distribution of drill.**—In connection with the question of the proper distribution of practice on the connections that are to be converted into permanent specific habits, the general principle that distributed practice brings better results than massed practice should be recalled.[1] In learning the fundamental combinations of arithmetic it appears that the number of repetitions should be relatively large and the intervals between practices relatively short during the initial stage of habit formation, and that the number of repetitions should gradually decrease and the length of intervals between practices should increase during the later stages of the process.

It is impossible to say exactly how many repetitions of each bond are needed and in precisely what manner these should be distributed. Thorndike[2] has estimated that in the case of an average pupil 67 repetitions of an easy connection[1] such as "$2 \times 5 = 10$, or $10 - 2 = 8$, or the double bond 7 = two 3's and 1 remainder," will be sufficient to attain, by the end of the sixth grade, the objective of 99.5 per cent accuracy in the functioning of the connection, provided the repetitions are properly distributed and "the teaching is by an intelligent person working in accord with psychological principles as to both ability and interest." The distribution of the repetitions recommended is as follows: twelve during the first week, twenty-five during the two months following, and thirty spread over the remaining period. For the more difficult combinations[2] 100 repetitions are estimated as necessary. Gifted children will require fewer repetitions, and those who possess less than average capacity to learn, a larger number of repetitions.

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[1] See pages 188–89.

[2] Thorndike, E. L.—*The Psychology of Arithmetic.* New York: The Macmillan Company, 1922, p. 133.

In considering the amount of practice needed, it is important to bear in mind that repetitions occur in the application of a habit as well as when it is singled out for isolated practice. For example, the addition combinations are exercised in doing addition examples involving several figures to the column as well as when the pupil responds to $6 + 7 = ?$, $9 + 8 = ?$, $13 + 5 = ?$, $24 + 7 = ?$, and the like. The combinations are exercised also in performing the calculations required in solving verbal problems. Hence, the total number of repetitions of a particular combination is the number of repetitions in isolation plus the frequency of its occurrence in examples and in the calculations required by verbal problems.

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[1] The reader should note that the connections or bonds referred to are facilitated by other bonds to a relatively high degree. This is one reason why they are "easy."

[2] There have been several investigations to determine the relative difficulty of the combinations. The most comprehensive study is CLAPP, F. L.—"The Number Combinations: Their Relative Difficulty and the Frequency of Their Appearance in Textbooks." Bureau of Educational Research Bulletin No. 2. Madison, Wisconsin: University of Wisconsin, July, 1924. 120 pp. In general, the more difficult combinations are those involving the large numbers, but there are many exceptions; especially those involving division combinations like: $2 \div 2 =$ , $8 \div 8 =$ , and $2 \div 1 =$ .

It appears that authors of textbooks in arithmetic have usually not properly planned the practice on each combination after it is introduced.[1] Hence, the teacher cannot safely assume that doing all the examples and problems in the book will result in the proper amount and distribution of practice. Some bonds will likely be over-exercised and others are certain to be neglected.

**Relation between rate and accuracy.**—A pupil's performance on a list of fundamental combinations or on a group of examples is commonly described in terms of the rate and accuracy of his response. Investigation has revealed that in general the pupils who perform the operations of arithmetic most rapidly make the fewest mistakes and those who are slow frequently make the most errors. This fact, however, should not be interpreted to mean that the accuracy of a pupil's work will be increased if he increases his rate of doing examples. Greater accuracy may result from an increase in the focalization of his attention upon the work, but the opposite effect may also be produced by his efforts to work rapidly.

A recent writer[2] has pointed out that a third factor is involved. Some pupils, especially in the lower grades, employ immature methods,[3] which make rapid work impossible. Hence they may be high in accuracy but low in rate. When they attempt more mature methods, the rate of work may be increased at the expense of accuracy until the new habits are firmly fixed.

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[1] See THORNDIKE, *op. cit.*, Chapters VI, VIII.

[2] BROWNELL, W. A.—"The Development of Children's Number Ideas in the Primary Grades," *Supplementary Educational Monographs*, No. 35. Chicago: University of Chicago, 1928, pp. 201f.

[3] Immature methods include counting on the fingers, "counting up" certain combinations from others such as 7 × 6 from 7 × 5 by adding 7 to 35.

As a rule the rapid worker is accurate because he has a superior mastery of the mechanics of the subject and consequently the correct responses are made promptly. The emphasis during the process of connection-building should be placed on accuracy. The pupil should be taught from the beginning to check his work. He should be led to assume the attitude that no operation has been completed until the result has been checked for possible errors. If accuracy is properly provided for, speed will usually take care of itself. In case it becomes apparent that a particular pupil is not working as rapidly as he could without sacrificing accuracy, he may be encouraged to greater speed by having him work under a time limit or compete with other pupils who work fast. In dealing with such cases, however, the teacher should first make certain that the pupil's methods are such that rapid work is possible without sacrificing accuracy.

**Understanding the reasons for each step in the various processes.**—Undoubtedly it is desirable that the pupil understand the reasons for the steps he takes in performing the various operations rather than that he perform them blindly. Such an understanding, however, is fortunately unnecessary to proficiency in the performance of the operations, since it is not feasible in many cases to develop it. It is doubtful, for example, whether the pupil can be led to see clearly, at the time he should learn to perform the operations, the reasons for the steps taken in borrowing in subtraction, or in inverting the divisor and multiplying when dividing by a fraction, or in carrying out the process of long division. Thorndike[1] believes that, although the reasons can be derived deductively, the pupil cannot, as a rule, grasp the deductions, but rather he comes gradually to some measure of understanding of the processes by performing them even though he does so at first blindly and irrationally. It seems that here, as in the spiritual realm, one comes to know the doctrine by doing the will.

**Types of examples.**—It is important that the teacher be aware not only of the large number of essential elementary facts which the pupil should master in arithmetic, but also of the wide range of the types of examples he must be prepared to deal with. Space cannot be taken here for a complete analysis of the types of examples, each type requiring mental activities that differ in some important respect from the mental activities required by any other type.[2] We must be content here with indicating the approach to such an analysis.

The term "example" is used as the name for an explicit request to add, subtract, multiply, or divide,[3] the numbers being given. The example may call for two or more of these operations to be performed, but in all cases the request is explicit. The request for the calculation may be expressed in terms of symbols, such as $694 + 27 = ?$, $37\overline{)\,848}$, or technical terms may be used, as "Find the product of 87 and 64," "Divide 694 by 27."

When considered as learning exercises, it is obvious that examples which differ in any way do not afford the basis for identical mental activities. The connections exercised by responding to 646 × 23 are different from those exercised by responding to 646 × 67. However, the difference is dissimilar to that existing between the responses to "subtract 746 from 9,286" and "divide $18\frac{3}{4}$ by $1\frac{5}{7}$." In the case of the responses to 646 × 23 and 646 × 67, we may say that they are similar in the sense that each involves the exercise of multiplication and addition combinations. This condition of similarity is expressed by saying all examples calling for the multiplication of a three-place integer by a two-place multiplier constitute a type. Examples such as 387 × 6 provide a sufficiently different learning activity to justify recognition as another type. A request to multiply 412 by 4 constitutes a third type, since no carrying is involved.

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[1] Thorndike, *op. cit.*, pp. 60–69.

[2] A list of sixty-six of the most important types of examples is recorded in Monroe, Walter S., and Clark, J. A.—"The Teacher's Responsibility for Devising Learning Exercises in Arithmetic." *University of Illinois Bulletin*, Vol. 23, No. 41, Bureau of Educational Research Bulletin No. 31. Urbana: University of Illinois, 1926, pp. 37–41.

[3] The extraction of roots may be added as a fifth calculation process.

Recognition of differences of the kind illustrated in the preceding paragraph raises the question, "What are the significant types of arithmetical examples?" Those involving only one calculation process fall naturally into four general groups: (1) addition, (2) subtraction, (3) multiplication, and (4) division. Within each of these groups three subdivisions are created by the three types of numbers: integers, common fractions, and decimals. Each of these twelve divisions obviously includes examples that differ in certain respects. Some of these differences have been recognized in arithmetic texts for many years by explicit "cases" such as "short multiplication," "subtraction with borrowing," and the like. However, the "cases" usually mentioned do not appear to constitute a complete enumeration of the types of examples. In addition a long column of figures (12 to 15) appears to constitute a different type of example from that furnished by a short column of figures (3 to 5). In multiplication the presence of zeros in the multiplier appears to create at least one separate type of example and possibly two.

**Ability to solve problems the goal in arithmetic.**—Thus far we have been concerned chiefly with the mastery of the mechanics of arithmetic, that is, the elementary facts to be learned and the types of computations in which skill is to be acquired. These accomplishments are of little value in and of themselves, but they are important because they are essential to the solutions of the problems that will be met in other school subjects or in life outside the school. Arithmetic is no longer regarded as being of value primarily because of the mental discipline it affords. Formerly many problems and types of problems were included in the textbook, not because it was expected that many, or even any, pupils would ever find it necessary to solve such problems in later years, but because of the supposed disciplinary effect of solving these problems. A different conception of the purpose of arithmetic is now held, and the aim of the subject is regarded as being to prepare the pupil to solve the problems he will encounter later. Whatever general value the training in arithmetic may have is not sacrificed by solving the kinds of problems that life is likely to offer rather than problems never encountered outside the study of arithmetic.

**The process of problem-solving in arithmetic.**—A problem may be defined as a description of a set of conditions involving quantitative elements plus a question whose answer, which is usually in quantitative terms, requires the performance of one or more arithmetical operations that are not explicitly indicated but which are to be inferred from the conditions stated. In general, the set of conditions described in the problem contains all the data needed in order to answer the question, provided the proper operations are performed upon them.[1] Such is not always the case, however. Thus, "What is the area of the earth?" is a problem, though the conditions are not so fully described as in the question, "What is the area of a sphere whose diameter is 7,900 miles?"

In order to illustrate the essential character of the process of problem-solving in arithmetic, let us consider the following problem and its solution.

> A hardware dealer buys a stove for $40. He marks it to sell for a profit of 30% of the cost. During a sale he reduces the marked price 15% and sells the stove. His gain is what per cent of the selling price?

The result is, of course, independent of the cost of the stove, and therefore it is not necessary to include any reference to $40 in the solution. It is likely, however, that the pupil will make use of the fact that the dealer paid $40 for the stove. His thinking, if he really thinks out the solution, will probably take some such course as the following:

He reads the problem and arrives at an understanding of the conditions described. In doing so he must, of course, assign the proper meanings to all the words and other symbols, among which are such technical terms as 30%, 15%, cost, profit, gain, and selling price. He determines just what question he is to answer and recognizes that, in order to answer it, he must know the gain and the selling price. He examines the statements in the problem and discovers that neither the gain nor the selling price is given. He then considers possible procedures for ascertaining these quantities. He considers the fact that the selling price is the marked price reduced 15%. Accordingly, if the marked price were known, the selling price could readily be found. The marked price is not known, but can be determined by adding to $40 the marked gain, which is 30% of the $40. He sees, then, that he is to begin with the cost, or $40, find the marked price, then the selling price, and finally the gain by comparing the cost and the selling price. He will then have the two quantities needed in order to answer the question. He has, by a process of thinking, determined what operations are to be performed and in what order they occur. He is now ready to construct the solution, which he may formulate as follows:

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[1] It is probably unfortunate that problems in textbooks almost invariably supply all the essential data and no irrelevant data. As a result of this practice the pupil soon concludes that everything given must be used and that the answer should always be obtained somehow from what is given. The problems he will later meet in life are not by any means always so conveniently formulated. If he is to do the best type of thinking in arithmetic in school and at the same time is to receive proper training for the problems later life will bring to him, he should learn to inquire just what must be known in order that the required answer may be found and to neglect irrelevant factors. It appears desirable, therefore, that he be given some problems in which some of the essential data are missing and some problems containing irrelevant data. In the case of missing data, he should be taught to consider whether they are obtainable from other sources. If they are, he should obtain them and complete the solution of the problem. If they are not, he should come to recognize that some problems cannot be solved until data, at present unavailable, can be secured.

.30 × $40 = $12, the marked gain
$40 + $12 = $52, the marked price
.15 × $52 = $7.80, the reduction in the marked price
$52 — $7.80 = $44.20, the selling price
$44.20 — $40 = $4.20, the gain actually made
$4.20 ÷ $44.20 = 9.5%, the gain as a per cent of the selling price.

Performing the operations involved in the written solution is a mechanical process, at least in the case of a pupil who is as proficient as is desirable in dealing with the types of calculation that are required in the solution. That is, carrying out the operations required in solving the problem should be a mechanical process rather than a process that demands thoughtful consideration and planning. The thinking that the problem demands consists in determining what operations are to be performed and in what order they will occur. It is this aspect of problem-solving that renders the process of value as a learning activity.

The foregoing illustration and discussion should enable the reader to grasp the significance of each statement in the following brief description of the manner in which pupils should solve problems: "Meanings are connected with words and symbols; the implied question concerning a functional relationship is identified and answered; denominate number facts are recalled; numbers are read and copied. The response, however, cannot be adequately described by enumerating the responses to such elements. Reflective thinking is involved. It should be noted that the total response to a verbal problem includes the determination of the calculations to be performed plus the response to the example formulated. Reflective thinking is involved in only the first phase of the total response."[1]

**How pupils solve problems in arithmetic.**—In an investigation by one of the present writers[2] for the purpose of throwing some light on the question as to how pupils really do proceed in solving arithmetical problems, ten problems were chosen from textbooks designed for the seventh grade. These problems were used in constructing four different tests which differed from one another with respect to technicality of the language, relevancy of all the data, and concreteness of the setting. These tests were distributed among 9,256 pupils in forty-one Illinois cities, practically 6,000 being in the seventh grade, and the others in the sixth and eighth grades. Hence, approximately 2,300 pupils took each test. The results may be briefly stated as follows: In terms of rough averages, about one-half of the pupils attempted each problem of the ten, and only about one-fifth of those who tried to solve the problem offered solutions that were correct in principle. Furthermore, when samplings of the papers[1] were analyzed to determine the number of different incorrect solutions that appeared, it was found that, on the average, each problem was solved incorrectly in about 125 different ways. The vast majority of the incorrect solutions gave no evidence that the problem was even partially understood. The author's general conclusion was: "Although the data of this investigation are not entirely consistent, they appear to substantiate the conclusion that a large per cent of seventh-grade pupils do not reason in attempting to solve arithmetical problems. Relatively few pupils follow the plan described on page 7. (This plan was quoted above on page 479.) Instead, many of them appear to perform almost random calculations upon the numbers given. When they do solve a problem correctly, the response seems to be determined largely by habit. If the problem is stated in the terminology with which they are familiar and if there are no irrelevant data, their response is likely to be correct. On the other hand, if the problem is expressed in unfamiliar terminology, or if it is a 'new' one, relatively few pupils appear to attempt to reason. They either do not attempt to solve it or else give an incorrect solution."[1]

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[1] Monroe, Walter S., and Clark, J. A.—"The Teacher's Responsibility for Devising Learning Exercises in Arithmetic," *University of Illinois Bulletin*, Vol. 23, No. 41, Bureau of Educational Research Bulletin No. 31. Urbana: University of Illinois, 1926, p. 22.

[2] Monroe, Walter S.—"How Pupils Solve Problems in Arithmetic." *University of Illinois Bulletin*, Vol. 26, No. 23, Bureau of Educational Research Bulletin No. 44. Urbana: University of Illinois, 1928. 31 pp.

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[1] The sample consisted of 250 papers of each of the four tests.

Since it appears that, in general, pupils do not think when asked to solve an arithmetical problem, it seems appropriate to consider some probable reasons for the failure to realize the primary aim of arithmetic.

**Vocabulary difficulties in arithmetic.**—It is obvious that the pupil cannot rationally solve a problem unless he clearly comprehends the conditions stated in it. In other words, he must be able to read the problem understandingly. This task is often difficult because of the presence of technical terms for which the pupil does not have adequate meanings. It is necessary that many technical words be used in stating problems, but their meanings should not be taken for granted. On the contrary, they should be taught with care and thoroughness, and a pupil should not be asked to solve a problem until it is certain that its statement includes no words that he does not understand.

Not all the language difficulties, however, are encountered in connection with technical terms. Non-technical, and hence non-essential, words that are not a part of the pupil's reading vocabulary are often used in stating problems, particularly in the lower grades.[2] This practice is, of course, the fault of the textbook writers, not of the teacher. Since the words are used in textbooks, however, the teacher is obliged to devote a portion of the time for arithmetic to instruction in reading. Assisting the pupil to read the problems understandingly will increase the likelihood that he will solve them rationally.

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[1] Monroe, Walter S., *op. cit.*, pp. 17–19.

[2] A list of rare and unimportant words taken from textbooks for the primary grades may be found in Thorndike, E. L.—*The Psychology of Arithmetic.* New York: The Macmillan Company, 1922, pp. 90–91.

**Understanding life-activities upon which problems are based.**—The inability to understand a problem, and hence to employ thinking in solving it, is not always due to vocabulary difficulties. The pupil may fail to understand the conditions of the problem because he does not have a clear conception of the nature of, or the practices prevailing in, the life-activity upon which the problem is based. For example, if the activities of a bank are clearly understood, problems involving bank discount will be solved thoughtfully and, as a matter of fact, will not be particularly difficult. The same is true for such topics as insurance, taxation, and commission. To assign problems relating to such topics as these without leading the pupil to a clear comprehension of the activities involved is to force him to proceed in some manner other than by reflective thinking.

**Lack of attention to the process of solving problems.**—Probably the most important reason for the failure of pupils to become proficient in solving arithmetical problems is the little attention given in our schools to the process. The extensive use of standardized tests[1] has tended to focus attention of both teachers and pupils upon the operations as objectives. Furthermore, when pupils are asked to solve problems, the attention frequently is upon the answer, and little consideration is given to the mental processes employed by the pupils. If the answer is correct, the pupil is considered to have made a satisfactory response to the problem. It is only when the answer is incorrect that attention is directed to the process, and frequently the instruction stimulates the pupil to attempt to memorize the plan of solving the problem rather than to develop skill in reasoning. Problem solving was described as a type of learning activity in Chapter VI,[1] but in the light of the available evidence it appears that pupil responses to the verbal problems of arithmetic involve much less of this activity than is generally supposed.

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[1] A few standardized reasoning tests have been used, especially during recent years, but their number is very small in comparison with the number of tests in the field of the operations of arithmetic.

**Types of problems.**—When we examine the problem lists in current arithmetics, we find a conspicuous lack of uniformity in the captions by which these lists are designated in different texts. Formerly, most of the problems given in an arithmetic were listed under such captions as: "Rule of Three, Direct," "Rule of Three, Inverse," "Partnership," "Alligation," "Barter," "Practice," "Profit and Loss," "Trade Discount," "True Discount," "Partial Payments," "Exchange," and so forth. Changes in business practices and in the activities of adults apart from the carrying on of business have created new "applications" of arithmetic. Many of the titles formerly used as captions for problem lists have been discarded and new ones substituted. The result is that at the present time we have no generally recognized plan for classifying the problems of arithmetic.

The buying and selling of commodities, borrowing money, constructing houses and other buildings, insuring property, carrying on a business, and the like create many arithmetical problems. This suggests that the sources of problems be used as a basis for their classification,[1] but such a plan will not give groups which approximate homogeneity with respect to the activity required in solving the problems. Furthermore, an examination of the content in our arithmetics will reveal a number of problems whose source is not easily identified. In some cases the problem does not appear to be connected with any particular activity or the suggested adult activity might be changed without affecting the problem. The following are typical:

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[1] See pages 211–12.

1. A pail of milk holding 2 gallons is to be poured into quart bottles. How many bottles will be needed?
2. Henry caught three fish. The first weighed 12 ounces, the second 10 ounces, and the third 15 ounces. What was the total weight of the three?
3. On a vacation trip Robert walked $6\frac{1}{2}$ miles the first day, 7 miles the second day, and $5\frac{3}{4}$ miles the third day. Find the total distance traveled.
4. The length of an iron rod was $95\frac{15}{16}$ inches. After it was heated its length was found to be $96\frac{7}{32}$ inches. How much was the length increased by heating?

In the first problem "milk" could be changed to "water," "syrup," or any other liquid without changing the problem. Furthermore, "bottles" could be changed to "cans" or "jars." Hence, there is no significant connection between the problem and any particular adult activity. A similar conclusion applies to the other problems.

Thus it appears that there are two general classes of problems: (1) operation problems (those not identified with a particular activity or identified with an activity that does not introduce a technical terminology peculiar to that activity); (2) activity problems (those identified with a definite activity of children or adults which introduces a technical terminology).

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[1] One of the present writers has employed this method of analysis. See Monroe, Walter S.—"A Preliminary Report of an Investigation of the Economy of Time in Arithmetic." Second Report of the Committee on Minimum Essentials in Elementary School Subjects. *Sixteenth Yearbook of the National Society for the Study of Education*, Part I. Bloomington, Illinois: Public School Publishing Company, 1917, pp. 111–27.

Within each of these two general classes of problems[1] a further differentiation may be based upon the implied question concerning the functional relationship. All problems that ask the same question may be considered to form a problem type which may be described by designating the quantities given and the one to be found. The question concerning functional relationship is: What calculations are to be performed upon the given quantities in order to obtain the one to be found?

Space will not permit us to list here the more common types of problems found in textbooks in arithmetic. One of the present writers analyzed ten texts to determine what types of problems occurred in them and found a total number of 333 types.[2] Since these represent, not 333 specific habits to be formed, as in the case of number combinations, but rather 333 generalizations to be grasped, retained, and applied, it appears that the problem load in arithmetic is not inconsiderable.

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[1] A verbal problem in arithmetic is a description of a quantitative situation or condition plus a question that usually requires a numerical answer. The solving of this requires the determination of the calculations to be made in order to obtain the answer. The basis of the determination of the calculations to be performed in the solving of a problem is the general quantitative relation which connects the quantities of the problem. For example, consider this problem: "An agent sells goods on a commission of 10 per cent. How much does he remit to his principal for sales amounting to $1,150?"

The quantities of this problem, proceeds (amount remitted to principal), rate of commission, and amount of sales are related as follows: Proceeds = amount of sales — the product of amount of sales and rate of commission. In order to solve this problem rationally, that is, by reasoning, it is necessary that one answer the question, "How is the amount to be remitted to the principal calculated from the amount of sales and the rate of commission?"

[2] These 333 types of problems are listed in MONROE, WALTER S., and CLARK, J. A.—"The Teacher's Responsibility for Devising Learning Exercises in Arithmetic." *University of Illinois Bulletin*, Vol. 23, No. 41, Bureau of Educational Research Bulletin No. 31. Urbana: University of Illinois, 1926, pp. 65–89.

**Problem cases in learning arithmetic.**—A few pupils experience much difficulty in learning arithmetic and a much larger number fail to attain a satisfactory degree of proficiency. Bronner[1] has reported several cases of pupils described as "normal, except for special disability in number work." Detailed diagnosis of these cases revealed as causes for the failure to learn arithmetic: poor auditory memory for numbers, "poor powers of forming associations with symbolic material," and lack of number concept. It also appeared that remedial instruction would not eliminate the special disability. There are, however, very few children of normal intelligence who are handicapped by a special disability in arithmetic.

Buswell[2] has reported an extensive diagnostic study which revealed that many pupils do unsatisfactory work in arithmetic because they have developed inefficient or incorrect "habits of work" such as "skipping about" in adding a column of figures, "forgetting to add the number to be carried," and skipping or dropping back a decade in adding. It was also found that in many cases teachers were not aware of "habits of work" which a pupil was employing. This was true even in the upper grades. Buswell explains this condition by pointing out that as a rule pupils receive very little instruction in regard to "habits of work" and are left largely to their own devices.

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[1] Bronner, A. F.—*The Psychology of Special Abilities and Disabilities.* Boston: Little, Brown and Company, 1917, pp. 56f.

[2] Buswell, G. T.—"Diagnostic Studies in Arithmetic," *Supplementary Educational Monographs*, No. 30. Chicago: University of Chicago, 1926. 212 pp.

The result is that not infrequently a pupil stumbles upon methods that are uneconomical or incorrect.[1] When the teachers became acquainted with the "habits of work" of their pupils they were able to provide instruction that corrected the fault.

**The measurement of achievement in arithmetic.**—Ability to perform the operations of arithmetic is the easiest phase of school achievement to measure, and a large number of standardized tests have been devised for this purpose. One type of test consists of a list of examples approximately equal in difficulty and the pupil is asked to do as many as he can in the time allowed. The resulting performance is usually described in terms of the "number attempted" and the "number right." Another type of test consists of a list of examples that represent levels of difficulty from very easy to very difficult. These examples are arranged in order of increasing difficulty and the pupil is usually allowed sufficient time to do as many as he can. His score is the "number right."[2]

The efforts of test-makers to devise instruments for measuring ability to solve problems have been less satisfactory. One reason for this becomes apparent when we consider the nature of ability to solve problems. If it is defined as the ability to overcome difficulties, to respond to *new* problems,[3] then the test should consist of problems that are "new" to the pupil. If it is defined as ability to respond to the particular problems the pupil has learned to solve, the variations in the content of texts make it difficult if not impossible to select a satisfactory list of problems. Another difficulty encountered by test-makers in this field is due to the fact that the solution of a problem includes the calculations necessary for obtaining the answer. Hence, in a pupil's response to a problem, his determination of the calculations to be made is combined with the calculations he makes. Although his performance may be scored for "correct principle," the nature of these calculations and any errors that he may make probably influence the reasoning phase of his response.[1]

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[1] Buswell, *op. cit.*, p. 195.

[2] Sometimes this score is transmuted into a "difficulty score."

[3] See page 308.

## IV. SPELLING

**The general nature of ability in spelling.**—A child who has learned to spell a word is able to give orally or to write the letters of that word in correct order in response to the spoken word or the idea of the word. In other words, he has acquired fixed associations between certain stimuli and certain muscular responses. When a mature speller is writing, the act of spelling familiar words receives relatively little of his attention. It is only when he desires to write a difficult word or a word seldom used that he focuses his attention upon the spelling.

Although the demand for spelling ability is chiefly in writing, it may function in reading, especially when there is need for distinguishing between words similar in form. A type of spelling ability is also involved in proofreading.

The fact that the chief demand for spelling is in writing implies that ability to spell means ability to write the letters of words in their correct order when writing sentences designed to express ideas rather than spelling words from dictated lists. It is obvious that the school cannot develop the ability to spell automatically every word that a person will ever have occasion to write. It is impossible to foresee precisely what words each person will ever write. Furthermore, the school could not take the necessary amount of time to give the required number of repetitions for all these words, even if they were known. Unless a word is to be spelled somewhat frequently, it is uneconomical to have the pupil master it thoroughly. Hence it appears that proficiency in spelling must be described partly in terms of ability to spell some words automatically and partly in terms of other abilities which we shall mention later.

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[1] For a more extended discussion of the measurement of achievement in arithmetic and a description of particular tests, the reader should consult some text that deals with these topics. The present writers recommend MONROE, WALTER S., DEVOSS, J. C., and KELLY, F. J.—*Educational Tests and Measurements* (Revised and Enlarged Edition). Boston: Houghton Mifflin Company, 1924, Chapter II.

**What words should be mastered thoroughly?**—Several studies have been made for the purpose of ascertaining what words are most frequently used in various kinds of writing, such as personal correspondence, business letters, newspaper items, magazine articles, and children's compositions in school. Ayres[1] has combined the results of four such studies and determined the one thousand most common words. Horn[2] has combined the results of several investigations and obtained a list of the ten thousand words most commonly used in writing. In view of the fact that Ayres reported that the one thousand words in his list make up more than ninety per cent of the written material from which they were taken, it probably is not desirable to require all of the words of Horn's list to be mastered. It is likely that the number should be between two and three thousand. Starch[1] has proposed a list of 2,626 words.

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[1] AYRES, L. P.—*Measurement of Ability in Spelling.* New York: Division of Education, Russell Sage Foundation, 1915, 58 pp.

[2] HORN, ERNEST.—"A Basic Writing Vocabulary: Ten Thousand Words Most Commonly Used in Writing," *Monographs in Education*, First Series, No. 4. Iowa City, Iowa: University of Iowa, 1926. 225 pp.

**The spelling of less common words.**—Although the ability to spell the most common words automatically is an important factor in proficiency in spelling, it alone is not sufficient. Many other words of less frequent occurrence will occasionally be written by most persons. Although these words may not be used frequently enough to justify their mastery by all pupils, it is important that a pupil be able to spell each of them when the occasion for its use arises. Hence, in addition to those words which the pupil should spell automatically, there are others which he should be able to spell by giving attention to the spelling. This act of attending to the spelling may involve a definite attempt to recall how the word is spelled, or to determine its spelling by sounding the word carefully by syllables, or by comparing it with related words whose spelling is familiar, or by applying some rule of spelling.

**An ideal of correct spelling.**—In addition to the ability to spell many words automatically and many others under attention, it is desirable that the pupil possess an ideal of accuracy in spelling. The effort to spell under attention does not always result in correct spelling. When it does not, accuracy depends upon the recognition of the error and a search in the dictionary or elsewhere for the correct form. This means that the pupil must place a sufficient value upon correct spelling to assure himself that each word is written properly. He should form the habit of checking all doubtful cases and making the needed corrections.

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[1] STARCH, DANIEL.—*Educational Psychology*, New York: The Macmillan Company, 1927, p. 382.

**Conclusions concerning the nature of spelling ability.**—From the point of view of the elementary school at least, spelling ability should be taken to mean the ability to spell correctly the words which the pupil has occasion to use in the written expression of thought. Since the amount and character of the writing done will vary widely among different persons, what may be regarded as a satisfactory level of achievement in spelling for one person may be far from satisfactory for another. Each person should be able to spell without attention to the process those words that he uses frequently in writing. For all persons, this requirement probably involves the two thousand or three thousand most commonly used words. In addition to these, each person should be able to spell many other words when attention is devoted to the spelling. Finally, each person should possess an ideal of complete accuracy in spelling, as a result of which he will look up all words about whose spelling he is uncertain.

**Initial formation of spelling associations.**—There are several ways in which a pupil may begin to learn to spell a word. He may listen to the teacher pronounce the word and repeat the letters forming it. This learning activity of listening may be supplemented by pronouncing the word and repeating the letters in imitation of the teacher. Another method is to look at the printed word, pronounce it and repeat the letters. Still another method is to write the word from a copy or the textbook. Experimentation to determine the relative merits of various methods has shown that the last one (copying) is superior, but it is generally agreed that it is best to use a variety of methods. One method will supplement another and, more important, a variety of methods will secure better adaptation to individual differences than can be obtained by employing a single method.

The order in which pupils should be asked to learn the words to be taught has received the attention of students of the teaching of spelling. In the early spellers the words were grouped according to size, and the pupil was expected to begin with words of two letters, then take up words of three letters, and so on, eventually coming to words having a large number of letters. This plan of grouping words has been discarded and it is now generally agreed that the child should be asked to learn to spell words at approximately the time he begins to use them in his writing. This principle, however, is very general, and there still remain questions concerning the grouping of words on the page of the text or in the daily assignments. The form of the words to be learned has been used as a basis for grouping. Some words, for example, such as *rate* and *hate*, have a series of letters in common. Some words are formed from others by adding a certain prefix or suffix. There are a few pairs of words, called homonyms, which are pronounced alike but have different spellings. It is probable that the best plan is to group together words that have a common difficulty, but this principle should be applied only to those words that are to be taught at about the same time.[1] Homonyms, for example, should be taught together only when both words appear in the child's writing vocabulary at about the same time. Furthermore, the members of a pair of homonyms may be grouped with other words having similarities of form and sound.

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[1] Tidyman, W. F.—*The Teaching of Spelling.* Yonkers: World Book Company, 1919, pp. 15f. Tidyman reviews the experimental evidence upon the question of grouping.

The efforts of the teacher should be in the direction of leading the pupil to build up correct associations during the initial phase of learning. The pupil should be led to examine the word carefully, particular attention being given to the part or parts that are most likely to be misspelled. The pronunciation of the word should be learned accurately, since mispronunciation is undoubtedly a cause of many errors in spelling. The division of the word into syllables and special emphasis upon the troublesome syllables[1] will be helpful.

As a part of the work in spelling, the pupil is usually expected to learn the meaning of each word in the lesson and demonstrate his knowledge of the meaning by using the word in a sentence. Thus the study of spelling results in an increased vocabulary on the part of the pupil. The practice could probably be justified, however, on the basis of the aid it lends to the learning of the spelling. One investigator[2] reports that children make about sixty-six and two-thirds per cent more errors in spelling when writing words whose meaning they do not know than when writing words of which they know the meaning.

**Incidental teaching versus drill methods.**—According to the formal, or drill, method, a special class period is provided for spelling. Words from a textbook or other word lists are assigned, and the pupil is expected to learn to spell these words by repeating their spellings a sufficiently large number of times. The number of new words learned each day is small, in many cases only two. Provision is made for the review of these words at intervals until they are thoroughly learned.

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[1] It is a rather common practice to write the words, divided into syllables, on the blackboard, the letters or syllables to which particular attention is desired being written with colored chalk, underscored, or made conspicuous in some other way.

[2] Hollingworth, L. S.—"The Psychology of Special Disability in Spelling," *Teachers College, Columbia University Contributions to Education*, No. 88. New York: Bureau of Publications, Teachers College, Columbia University, 1918. 105 pp.

The incidental method dispenses with spelling textbooks and special class periods devoted to spelling. The pupil learns to spell words as they chance to appear in his regular school work, particularly in reading and writing. Some attempt may be made by the teacher to impress the spelling of the word on him, and special emphasis is placed on the word in case the pupil misspells it in his written work.

There has been some dispute as to the relative effectiveness of these two methods. The drill method offers the following apparent advantages: (1) it presents a selected and graded list of words to be learned; (2) it provides for such frequency and distribution of the repetitions of these words as will be in agreement with the principles of habit formation; and (3) it guarantees that spelling will not be wholly neglected by teacher or pupil. It does not, however, always yield satisfactory results. The reason appears to be that mere repetition, without attention and the desire to learn, too often characterizes the drill method. Mechanical, monotonous, purposeless drill never represents efficient learning activity. Furthermore, the fact that a special class period is given over to spelling may cause the teacher and the pupil to give too little attention to spelling in connection with the other school work. If the tendency to neglect spelling throughout the remainder of the day is coupled with an ineffective type of drill during the spelling period, the total result is likely to be disappointing.

The incidental method avoids the danger of ineffective drill, stimulates the teacher to be more attentive to spelling at all times, and focuses the pupil's attention upon those words which he is actually using. While it avoids the uneconomical expenditure of time that accompanies the use of poor procedures in drill, it does not appear to offer advantages equal to those possessed by good methods of drill. In addition to theoretical considerations, there is experimental evidence[1] pointing to the conclusion that proper drill methods are more effective than the incidental method.

**Spelling by sound.**—It is obvious that knowing the sound values of the letters and of various frequently met combinations of letters will be a great help to the pupil in learning to spell.[2] This is true both in learning to spell new words and in remembering the spelling thereafter. Without a knowledge of the sound values of the letters, the learning of the spelling of a word, as well as its recall when it is needed later, is a process of associating symbols that are practically meaningless and arbitrary. It is a well-known fact that the mechanical memorization and the retention of meaningless symbols is a much slower and a more difficult process than is the learning and recall of meaningful symbols. Hence the pupil should, so far as it is possible, always spell by sound. That is, he should analyze the word into its phonic elements and then associate these elementary sounds with the letters that represent them.

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[1] Perhaps the most valuable evidence of the superiority of the drill method is furnished by Wallin. See WALLIN, J. E. W.—*Spelling Efficiency in Relation to Age, Grade, and Sex, and the Question of Transfer.* Baltimore: Warwick and York, Inc., 1911. 91 pp.

[2] The importance of this knowledge in learning to recognize new words in reading has been pointed out in the discussion of this subject. (See p. 451.) Perhaps this knowledge, for the most part, will more properly be gained from the instruction in phonics in connection with reading. But it should be applied—and it will, of course, be strengthened through the application—in spelling.

Phonic spelling in English is rendered difficult by the fact that there is not a single, invariable sound value assigned to each letter or combination and to no other. A letter may have a number of sound values, and a given sound may be expressed by more than one letter or combination of letters. Thus consider the different sound values of *a* in *fate*, *fat*, *fall*, *far*, *fare;* also, the various ways of expressing the long *o* sound in *go*, *throw*, *hoe*, *beau*, *dough*, *sew.* In spite of such irregularities and complexities, however, English orthography is not an utter chaos, and there are a number of rules that specify the spelling of certain classes of words.

**The value of rules in spelling.**—Convincing experimental evidence on the question of the value of rules in spelling is lacking. Some of the rules are difficult for the pupil to understand, remember, and apply. The helpfulness of many of these rules is further diminished by the fact that they have numerous exceptions which must be learned and remembered. There are at least a few rules, however, which, it would seem, should prove helpful. For example, the rules governing the addition of *ing* to words ending in *ie* and the formation of plurals of singulars ending in *y* are cases in point. The knowledge of such rules, when they are applicable, should aid the pupil in deciding doubtful cases or in recalling the spelling of words which cannot be spelled without attention to the process.

**The existence of general elements, or factors, in spelling ability.**—The spelling books in common use a few decades ago contained a large number of uncommon and difficult words which children were required to learn to spell. In accordance with the faculty psychology and the doctrine of formal discipline then in vogue, the mastery of the words in such a textbook was believed to develop a general power to spell, as the result of which the pupil should be able to spell all words that he would ever have occasion to spell. With the decline of faculty psychology and the doctrine of formal discipline, spelling ability began to be regarded as a composite of an enormous number of specific abilities rather than a general ability. According to this view, each of the many specific abilities is, of course, the ability to spell a particular word and is independent of the ability to spell any other word.

It appears that both of the views just mentioned are extreme and that, while spelling ability consists in large part of a multitude of specific abilities, it may also involve elements that are somewhat, if not entirely, general in scope. We have already spoken of spelling by sound and of knowing and applying general rules to particular words. In so far as these procedures may assist in spelling, we may speak of elements of ability that are not specific, that is, not restricted to one word only. The same may be said of other generalized controls of conduct, such as the conviction that correct spelling is worth while, or the habit of verifying all doubtful cases of spelling, or the knowledge of how to locate a word in the dictionary in order to determine the correct form, or the habit of observing new words closely when they are encountered.

It does not, of course, follow from the belief in general factors in spelling ability that the present tendency to emphasize words which the pupil will use rather than rare and difficult words is not wholly justifiable. Whatever general factors may be included among the objectives of the instruction in spelling can be developed as readily through the study of the common, useful words as through attention to difficult words that the pupil will seldom or never use. The acquisition of the general elements in spelling ability depends upon the method of instruction rather than upon the content of the textbook. It is especially important that the pupil be led to value accuracy in spelling and to practice it in connection with all written work instead of giving it attention only during the special class period devoted to that subject.

**Special disability in spelling.**—Some children who otherwise have good school records become known as "poor spellers." Occasionally an educated adult is known among his associates as a "poor speller." It appears that a few children are unable to learn to spell and that a larger number are markedly deficient in ability to learn to spell. It also appears that disability in spelling is not due to low intelligence. Hollingworth[1] states that there are marked individual differences in spelling ability on every level of intelligence and that "in rare cases children who are of superior general intelligence may be unable to master spelling." This writer believes that in a very few cases failure to learn to spell is due to limitations in the child's original nature; but she adds: "Over eighty per cent of the poor spellers in our Experimental Class spelled poorly from some cause other than special disability. General intellectual weakness, lack of interest, distaste for mental drudgery, intellectual inertia, previous learning in a foreign language, sensory defects, and bad handwriting are doubtless the most frequent causes of poor spelling."[2] In reporting a more recent study Gates[3] is inclined to reject the hypothesis of special disability in spelling proposed by Hollingworth and takes the position that inability to learn to spell is due to a combination of causes of the type listed in the above quotation.

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[1] Hollingworth, L. S.—"The Psychology of Special Disability in Spelling," *Teachers College, Columbia University Contributions to Education*, No. 88. New York: Bureau of Publications, Teachers College, Columbia University, 1918, p. 100.

[2] *Ibid.*, p. 74.

[3] Gates, A. I.—"The Psychology of Reading and Spelling with Special Reference to Disability," *Teachers College, Columbia University Contributions to*

**The measurement of ability in spelling.**—It is impossible to obtain entirely satisfactory measures of spelling ability. If words are dictated to the pupil and written in column form, attention is given to the spelling. If he spells them correctly in such a case, it is not certain that he could spell them without attention to the process. If the words are embedded in sentences and the pupil is required to write these from dictation, he may devote less attention to the spelling than when he writes the words in columns.[1] The writing of dictated sentences, however, is not the same type of activity as writing sentences when the pupil constructs them in expressing his thoughts. If free composition is used as a basis for the measure of spelling ability, the result is not satisfactory because different pupils will use different words and it would be impossible to establish norms.

The efforts of test-makers in the field of spelling have been devoted largely to the determination of the words that pupils should be asked to spell. The first determination was made by Ayres, who arranged his list[2] in the form of a spelling scale by determining the difficulty of the words and classifying them on the basis of their difficulty. The words of each group are approximately equally difficult for school children of a given grade. This

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*Education*, No. 129. New York: Bureau of Publications, Teachers College, Columbia University, 1922. 108 pp.

[1] There is experimental evidence indicating that the results obtained from column spelling and from spelling in dictated sentences are practically the same. For example, see WALLIN, J. E. W., *op. cit.*

[2] See page 489.

classified list, together with the per cent of correct spellings in each of the grades, has been printed with the title, *Measuring Scale for Ability in Spelling.*[1] To use the Ayres Scale, a suitable number of words for a test are chosen from one of the columns appropriate for the grade in question and are dictated to the pupils. The average score in per cent for the class is found and compared with the norm for that grade as reported at the head of the column from which the words were taken. The spelling ability of an individual pupil may, of course, be described in terms of the grade norm which his score reaches.

Starch has compiled a list that may be used in a similar manner.[2] This list contains 2,626 words. Starch distributed these words among the eight grades, assigning 106 of them to the first grade and 360 to each of the other seven grades. He then divided the words assigned to the first grade into two lists of fifty-three words each and the words for each of the other grades into six lists of sixty words each. These various lists were then given to approximately seven thousand children at the end of a school year and average grades in per cent computed for each school grade.[3]

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[1] For a more complete account see Monroe, Walter S., DeVoss, J. C., and Kelly, F. J.—*Educational Tests and Measurements* (Revised and Enlarged Edition). Boston: Houghton Mifflin Company, 1924, pp. 206f.

[2] Since the words in each column of the Ayres Scale are of approximately equal difficulty, any method of sampling the column is permissible. In the case of the Starch list the word list for a given grade does not contain words of uniform difficulty. Hence Starch recommends that, in selecting words for a test, the teacher should begin with any one of the first six words and choose every sixth word thereafter.

[3] For a more extended account of the measurement of spelling ability see Monroe, Walter S., DeVoss, J. C., and Kelly, F. J., *op. cit.*, pp. 205f.

## LEARNING EXERCISES FOR THE READER

1. What is meant by the psychology of a school subject? For example, psychology of reading?

2. Contrast the handwriting movements of an unskilled penman with those of a skilled penman.

3. What were the weaknesses of the once-prevalent "copybook method" of teaching handwriting?

4. How may handwriting scales be used effectively in teaching handwriting? How should the use of an analytical scale and a general merit scale be coördinated?

5. Should defective eye-movements be regarded as causes or as symptoms of inferior reading ability? Explain.

6. Try the following experiment. Ask some person to read aloud a paragraph from a book held on a level with his eyes. Stand before and to the right (or left) of the person reading and observe the eye-movements. Can you count the number of fixations in each line? The number of regressive movements?

With a small amount of practice you should be able to make such counts fairly accurately. How could you obtain an approximately correct measure of the average length of pauses?

7. What remedial instruction do you think would prove helpful in the case of a pupil whose eye-movements are inferior?

8. Consider the stanza of "The Destruction of Sennacherib" and the interpretations by the pupils mentioned. Point out the things each pupil needed to know, but apparently did not know, in order to interpret the stanza satisfactorily.

9. What cultural values has arithmetic?

10. What is the difference between counting and repeating the number names in order?

11. Show how the meaning of each of the fundamental processes may be developed through counting.

12. What is the distinction between an example and a problem?

13. What is meant by "types of examples"? "Types of problems"?

14. When may one be said to have attained a satisfactory level of ability in spelling?

15. Explain why the measurement of achievement in spelling is difficult.

16. Is ability in spelling a generalized ability or a composite of a large number of highly specialized abilities?

17. Suggest questions concerning the psychology of each of the subjects discussed in this chapter to which you think a teacher should know the answers but which are not answered in this chapter. The psychology of school subjects is fragmentary. Your response to this exercise will furnish an indication of the need for research in this field.

# CHAPTER XIII

# THE PSYCHOLOGY OF HIGH-SCHOOL SUBJECTS

**Introductory statement.**—This chapter is devoted to the psychology of (1) algebra, (2) geometry, (3) English composition, (4) the natural sciences, and (5) the social sciences. Since these school subjects are more complex than those considered in the preceding chapter, and, furthermore, since there have been relatively few studies of learning on the high-school level, we find it more difficult to describe the abilities to be engendered and the nature of the learning processes. Inasmuch, however, as high-school teachers, as well as those in the elementary school, must stimulate and direct learning activities, it seems desirable to offer some treatment of the subjects listed.

## I. Algebra

**The nature and function of algebra.**—It was pointed out in the preceding chapter in connection with the discussion of arithmetic that numbers are abstractions. If we speak of a group of four boys, for example, we disregard their heights, ages, dress, nationality, and so on and attend to the how-many-ness of the group. In other words, we abstract from all the aspects of the group only the quantitative element. In arithmetic the how-manyness aspect of groups of objects is always expressed in definite terms. We deal with particular numbers for the purpose of obtaining particular results. In algebra, however, we are concerned only incidentally, if at all, with particular numbers and particular results. We deal, rather, with the general laws governing operations with numbers. Algebra is thus somewhat more abstract than arithmetic, but especially is it more generalized than the latter.

Strictly speaking, therefore, algebra should not be spoken of as being merely an extension of arithmetic. In order to deal with general numbers and to formulate the laws governing the operations upon general numbers, it is necessary to extend the number system which is adequate in arithmetic to include negative numbers and imaginary numbers. Furthermore, since the numbers are general rather than particular, they are represented by letters. But algebra is not simply arithmetic with literal, negative, and imaginary numbers added. It is fundamentally a consideration of numbers with a different purpose or from a different point of view—that, namely, of the general laws governing the operations upon them.

We may distinguish two valuable purposes which are served by an understanding of these laws and the ability to apply them. In the first place, when the numbers and their relationships are kept on a perfectly general plane, we have a brief, concise, convenient way of expressing and treating quantitative relationships that obtain in nature and are matters of primary concern in the various sciences. For example, the physicist discovers that the strength of an electric current furnished by any number of like cells connected in parallel may be calculated by dividing the voltage of one of the cells by the sum of (1) the resistance offered by the external circuit and (2) the internal resistance of one cell divided by the number of cells used. He expresses this general law symbolically thus:

$$C = \frac{E}{R + \frac{r}{n}}$$

This statement is a very convenient formulation of the law and, to one who understands the language of algebra, a more meaningful statement than is a verbal one. By manipulating this formula in accordance with the general laws applicable in such a case, the relationship that any element in it bears to the others may readily be determined. On account of the service algebra thus renders in various fields of study, it is often spoken of as a tool subject.

Algebra performs a second type of service: it aids in the solution of many problems in which particular numbers are to be manipulated to obtain a particular result—solutions wherein the ordinary methods of arithmetic would prove clumsy and inconvenient, if not inadequate. For example, consider the problem: How many ounces of a 5% salt solution must be mixed with 18 ounces of a 20% solution to obtain a 14% solution? A convenient solution of the problem requires that some symbol be used to represent the unknown amount of the 5% solution. The use of this symbol makes it possible to represent also the amount of the total mixture, and to formulate a statement of the relationships existing among the three solutions involved. This statement, or equation, can be manipulated according to the general laws that are applicable, and the desired number can be ascertained.

**The nature of ability in algebra.**—The last few decades have witnessed a marked change in the conception of the proper range and content of the subject itself. This changed attitude toward the proper subject matter of algebra has doubtless resulted from, or at least been influenced by, the decline of faculty psychology and the doctrine of formal discipline, and is comparable to the corresponding change noted in connection with the subject of arithmetic. Thorndike[1] distinguishes the algebra prior to 1910 from the algebra since 1910 by speaking of the former as the "older" algebra, which included many exercises and problems never encountered outside of the course in algebra, and in which the order of topics closely paralleled the order of the topics in arithmetic. Just as spelling formerly was taught with the view of cultivating a general power to spell which would guarantee the spelling of any word, so the older algebra sought to develop the ability to perform a variety of operations on algebraic expressions, many of which were altogether unique to the subject.

No precise and generally accepted definition of the abilities in algebra has been formulated. To define the manipulative skills in algebra, we should have to know what operations the learner should become able to perform and also the range of the types of expressions upon which each is to be performed, as well as the rate and accuracy with which the manipulations of symbols need to be made. The pupil must, of course, be able to add; but what kind of examples should he be efficient in doing? Is it enough that he be able to find the sum in cases like example (a), or should he be able to do examples like (b), or even more difficult ones?

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[1] Thorndike, E. L., and others.—*The Psychology of Algebra.* New York: The Macmillan Company, 1923, pp. 96f.

(a)
$$\begin{array}{r} 2a + 3b - c \\ a - 4b + 2c \\ 3a + 2b + 3c \\ \hline \end{array}$$

(b)[1] Simplify the following polynomial:

$$ax - \tfrac{3}{2}ax^2 - \tfrac{1}{4}ax^3 + \tfrac{3}{2}ax^3 - \tfrac{1}{2}ax^2 - \tfrac{1}{6}bxy + \tfrac{1}{2}bxy - \tfrac{3}{4}ax^3 - \tfrac{7}{6}ab + \tfrac{2}{3}bxy - \tfrac{5}{6}ab + \tfrac{7}{2}ax + 2ab - \tfrac{3}{2}ax + \tfrac{5}{4}ax^2.$$

Although it is impossible to specify in detail the abilities to be acquired in each case, it is possible to list a number of elements, or aspects, of ability in algebra and to describe each in general terms.

1. *Concepts.*—Adequate meanings for many technical terms—such as exponent, coefficient, radicand, quadratic equation, root, and factor—are needed. Thorndike estimates that the number of such terms is about two hundred and fifty.

2. *Rules and principles.*—A large number—about one hundred and fifty, according to Thorndike—of rules, principles, laws, and axioms must be learned. Examples are:

The product of two like-signed numbers is positive.

Both members of an equation may be multiplied by the same number without affecting their equality.

The product of the sum and the difference of two numbers is equal to the square of the first minus the square of the second.

The last term of an arithmetic progression is equal to the first term plus the product of the common difference and the number of terms decreased by one.

3. *Operations, manipulations, computations.*—It was pointed out in the preceding chapter that a classification of the examples encountered in arithmetic reveals a relatively

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[1] Taken from a textbook in elementary algebra.

large number of types, each of which demands a set of mental processes significantly different from those required by any other type. So far as the present writers are aware, a corresponding classification for the operations of algebra has not been made. If it were made, it would probably result in a surprisingly large number of types. Many of them—as, for example, solving a set of simultaneous linear equations containing three unknowns, or solving a literal quadratic equation by completing the square—would involve a number of steps or operations demanding considerable manipulative skill.

The difficulties that pupils encounter in carrying through the various processes of algebra consist in determining what step is to be taken first, what step next, and so on, rather than in performing the operations in each step. In this respect, most of the work in algebra is similar to problem-solving in arithmetic, in which the difficulty lies chiefly in deciding what operations to perform. Reeve[1] has reported that only 19 per cent of 1,200 pupils were able to solve for $r$ in the equation $S = \frac{a}{1 - r}$. The steps which may be taken in this case are:

(1) Multiply S by 1 — r $\quad S - Sr = a$

(2) Transpose S $\quad -Sr = a - S$

(3) Divide by —1 and rearrange right member $\quad Sr = S - a$

(4) Divide by S $\quad r = \frac{S - a}{S}$

It is hardly likely that the pupils tested would have found it difficult to carry out these operations if they had been explicitly asked to perform each one separately. Ability in computation, in short, consists not only in being able to perform designated operations, but also—or, rather, chiefly—in being able to determine, step by step, what operations are to be performed.[1]

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[1] Reeve, W. D.—*A Diagnostic Study of the Teaching of Problems in High School Mathematics.* Boston: Ginn and Company, 1926.

4. *Formulas.*—The formula is a special case of the equation—an equation containing more than one variable and expressing a relationship among these variables which has actual and practical applications. An adequate mastery of a formula includes: (1) an understanding of its meaning—that is, the ability to translate it into words; (2) the ability to construct it from the verbal statement of the relationships of which it is the symbolical expression; (3) the ability to solve it for any one of the variables in terms of the others; (4) the ability to substitute given values for all the variables except one and to simplify or to obtain the value of the unknown; (5) the ability to determine by inspection the general nature of the effect upon one variable of a change in the value of another variable.

5. *Problems.*—The ability to solve problems in algebra involves (1) the ability to construct the equation or equations expressing given relations among the data (assuming that the data are adequate), and (2) the ability to solve the equation or set of equations, if the solution is possible by means of the methods taught in elementary algebra. The former, of course, involves reasoning, though it may be of a low order in case the equations are formed by a

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[1] The difference between the ability to solve algebraic equations and the ability to perform arithmetical calculations is largely a difference in degree of habituation. If the learning of pupils were extended sufficiently, ability to solve equations would become similar to the ability to do arithmetical examples; but to secure this result a far greater amount of drill would be required than is commonly given in teaching first-year algebra.

more or less blind process of imitation of models provided by teacher or textbook. As algebra is often taught, it is probably correct to say that the construction of equations in problem-solving is the only part of the work in the subject in which reasoning is expected to play a significant part.

6. *Graphs.*—The inclusion of graphical work in algebra is a relatively recent innovation. Whether the graph logically belongs in algebra or not, it is now generally included in our texts. Hence, ability in algebra includes the ability to construct and to interpret the simpler forms of both statistical and mathematical graphs. As usually treated, the latter includes only those cases corresponding to equations that are dealt with in elementary algebra—that is, the straight line, the circle, the ellipse, the parabola, and the hyperbola.

**Acquiring skill in algebraic manipulations.**—It is evident that a great deal of repetition, or drill, is necessary in acquiring skill in manipulating the symbols of algebra. To understand and to remember how to factor a given type of expression, or to solve a set of simultaneous equations, or to extract the square root of a polynomial, and to become able to carry out such operations rapidly and accurately, the learner must perform each type of operation many times. Likewise repetition is essential in learning and retaining general meanings, rules, and principles, in acquiring power in formulating equations, and in interpreting and constructing graphs.

It can never be overemphasized, however, that, in algebra as elsewhere, mere repetition does not guarantee the attainment of the desired outcomes. Reports of the errors that pupils make in attempting to solve relatively simple equations indicate that our present teaching is unsatisfactory. It seems likely that, in the present teaching of algebra, enough time is spent in drill. If this hypothesis is true, the change needed is in some other phase of the instruction.

The writers' limited observation of algebra teaching leads them to believe that too much emphasis is placed upon having pupils try to fix in mind the steps to be taken in carrying out a given type of process, and too little attention is given to the meaning of the operations. Suppose, for example, the pupil is to learn to solve simple equations containing expressions in parentheses, such as:

$$2(2x - 1) = 4(x - 5) - 3(x - 2)$$

He is told, let us say, to follow these steps:

(1) Multiply each expression in parentheses by the coefficient.
[Result: $(4x - 2) = (4x - 20) - (3x - 6)$]
(2) Remove all parentheses.
[Result: $4x - 2 = 4x - 20 - 3x + 6$]
(3) Transpose all terms containing x to the left member of the equation and all other terms to the right member.
[Result: $4x - 4x + 3x = -20 + 6 + 2$]
(4) Collect. [Result: $3x = -12$]
(5) Divide by coefficient of x. [Result: $x = -4$]

The pupil may memorize this set of steps and carry through the process, obtaining the correct result, yet never consider the meaning of anything he has done, nor ever be conscious that he was working with numbers. Any change in the conditions, such as the introduction of a denominator under one of the expressions, may render him helpless. Furthermore, when this type of process has been drilled upon and then abandoned for a short time in favor of other types of processes, his memory of the steps and their order may fail him, and he no longer be able to solve such an equation.

Everett[1] distinguishes two types of skills in algebra—namely, manipulative skills and associative skills. He finds forty-four of the latter, some examples of which are:

> 1. [Knowing that] the number scale contains both the positive and negative numbers, but that the scale does *not* begin at 0 and *run in opposite* directions.
> 2. [Knowing that] the sign of the number to be added to another always indicates the direction of the addition on the number scale.
> 3. The recognition of the meaning of fractions expressed in terms of the same fractional unit.
> 4. [Knowing that] the third term of a result obtained by multiplying a binomial by itself may be obtained from the other two terms.

According to Everett's view of the correct procedure in learning algebra, drill upon any process should include attention to the pertinent associative skills, and not simply the manipulative skills. Hence all the operations of algebra afford opportunities for thinking, and should never become merely mechanical processes in which a series of steps are carried out imitatively with meaningless symbols.

As in all cases of learning where many repetitions are required, the principle of distributed practice should be observed in drill in algebra. It was pointed out in the discussion of arithmetic that the amount and the distribution of practice upon each connection to be formed are not well provided for in all, if indeed in any, of our textbooks. The same situation prevails in the case of algebra. Thorndike[1] has shown that the manner in which several widely used textbooks in algebra distribute the drill upon a number of different types of processes differs widely from the kind of distribution that would seem theoretically to be most economical and effective.

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[1] EVERETT, J. P.—"The Fundamental Skills of Algebra," *Teachers College, Columbia University Contributions to Education*, No. 324. New York: Bureau of Publications, Teachers College, Columbia University, 1928. Chapters V and VI.

**Acquiring concepts, rules, principles, and understanding of operations.**—The usual approach to meanings, rules, principles, and processes in algebra is deductive. The pupil is first given a statement of the definition, rule, or principle, or an explanation of a process; then a few illustrative cases are examined, with the expectation that, by this stage of the procedure, the pupil will have acquired a clear understanding of the definition, rule, or process; and finally, the pupil is led to apply what he is assumed to have learned to a number of practice or drill exercises. In speaking of this approach to the acquisition of meanings, Thorndike says: "The assumption seems to have been that the learner got the meaning substantially from the definition, and made sure of it from the illustrations. Whatever the merits of the method of teaching, this assumption was almost certainly not true save perhaps for a very few of the most gifted pupils."[2] Again, in speaking of the deductive presentation of rules and principles of computation he says: "Modern psychology, however, is suspicious of all cases where habits are supposed to be easily derived from principles. It so often happens that the really effective principle is the product of the habits, not their producer."[3]

The acquisition of meanings, rules, and principles, and the mastery of processes of computation cannot, then, if Thorndike is right, be handed over ready-made to the pupil. He must make these acquisitions through repetition, or drill. But we have pointed out in a preceding paragraph that drill does not inevitably bring the desired results—probably will not if attention is restricted to what Everett calls the "manipulative skills" to the exclusion of the "associative skills." Consequently, the learner's attention should be directed to the "associative skills."

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[1] THORNDIKE, *op. cit.*, pp. 369f.

[2] *Ibid.*, pp. 240–41. (By permission of The Macmillan Company.) The student should read the entire chapter from which the quotation is taken.

[3] *Ibid.*, p. 245. (By permission of The Macmillan Company.)

**Learning to solve problems in algebra.**—A problem in algebra should be thought of in terms somewhat different from those involved in an arithmetical problem. In solving the latter the pupil faces the task of deciding what operations are to be performed. In solving an algebraic problem the important task is translating the relationships given in the problem into algebraic equations. The formation of one or more equations is the primary step—and usually the most difficult one—in problem-solving in algebra.

Some reasons for failure in problem-solving in arithmetic were pointed out in the preceding chapter. These were: (1) the problem is often stated in language that the pupil does not understand clearly; (2) the pupil may not have an adequate insight into the life activity involved in the problem; and (3) the pupil's lack of proficiency in the mechanical aspects of the solution may serve to distract his attention from the necessary thought processes. Similar difficulties may be encountered in problem-solving in algebra.

As in arithmetic, the problem content of textbooks in algebra is open to the criticism that many of the problems will never be encountered elsewhere than in the algebra course. Many of them are of relatively little importance even though it is conceivable that they may be met elsewhere. Thorndike[1] has analyzed the problem content of two texts, counting the problems that are "real" (in the sense that they could be framed without a fore-knowledge of the answer) and "important" (in the sense that it would probably be of some value to the pupil to be able to solve such a problem outside of the course in algebra). Rather liberal standards were followed in both ratings. The results were: One text contained 491 problems, of which only 96 were rated as "real" and "important," and 35 of these could better be solved without recourse to algebraic methods. Hence, only 61 problems remained as suitable for the course in algebra. Furthermore, 12 of these did not require the formulation of an equation, and hence only 49 survived all the criteria for suitable problems. A second book was analyzed in a similar manner, and 53 suitable problems were found in a total of 412 problems.[2]

Thorndike's analysis indicates that difficulty in understanding algebraic problems is a potent cause of failure in solving them. A pupil must understand the relationship, explicitly expressed or implied, in order to translate the conditions of the problem into algebraic equations. Facility in translating relationship into equations requires the ability to think in terms of the symbols used. The symbol $x$ is highly abstract. It means one thing in one problem and something else in another. Hence learning to formulate equations is, in some respects, similar to learning to think in a foreign language.

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[1] THORNDIKE, *op. cit.*, Chapter V.

[2] Thorndike suggests that a better choice of problems would probably result from discontinuing the traditional practice of trying to find problems to fit each of many different topics—such as multiplication, parentheses, factoring, fractions, simultaneous linear equations, and the like—and selecting a number of worthwhile problems to be solved by any applicable techniques.

**Relation between ability in algebra and general intelligence.**—Numerous investigations of the relation between ability in algebra and general intelligence have been made.[1] The coefficients of correlation obtained in these studies range from .38 to .64. Thorndike has corrected these correlations for inaccuracies in the measurements and also for the difference between the variabilities of the groups studied and the variability of the unselected adult population, and has arrived at the conclusion that "the correlation between algebra and intelligence is .80 when taken over the total range of the unselected adult population. For high-school freshmen as a group this correlation would be in the neighborhood of .70."[2]

This very marked relationship between ability in algebra and general intelligence indicates that in general a pupil's success in algebra depends upon his mental age. The normal mental age for pupils studying first-year algebra is approximately 15 years. Hence those having a mental age much below this norm are not likely to do satisfactory work. It should be noted, however, that as in all cases of learning, other factors than intelligence affect a pupil's achievement. Consequently a pupil of somewhat inferior intelligence may attain a relatively high degree of achievement, and some pupils of superior intelligence may fail to do satisfactory work. Thorndike states that seventeen of the brightest twenty-two pupils in a hundred will be above the average in algebra, and seventeen of the twenty-two most stupid will be below the average. He also says that a pupil who scores below 100 on Army Alpha is unfitted for algebra, and that it would not be an unreasonable estimate to state that an Alpha score of 105 or 110 is necessary for the successful pursuit of the subject. This standard would exclude about 60 per cent of all pupils entering high school.

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[1] The results obtained in a number of these studies are reported in THORNDIKE, E. L., and others.—*The Psychology of Algebra.* New York: The Macmillan Company, 1923, pp. 420f.

[2] THORNDIKE, *op. cit.*, p. 425. (By permission of The Macmillan Company.)

**Measurement of achievement in algebra.**—The measurement of skill in algebraic manipulations can be accomplished by employing tests of the types described for the operations of arithmetic,[1] but in constructing appropriate measuring instruments it is necessary to have at hand adequate definitions of the abilities to be measured. In the field of arithmetical calculation such definitions are available,[2] but, as pointed out on page 506, our present definitions of algebraic abilities are not satisfactory. Since addition, subtraction, multiplication, and division are recognized as topics in algebra, it may appear that these operations are fundamental, and hence that an instrument for measuring achievement in algebra should include a test on each of these operations as in the case of arithmetic. Analysis of the process of solving equations, which constitutes the large central topic of algebra, reveals, however, that the demands for these operations are limited to a few simple cases—such as collecting terms (addition); transposing terms (subtraction); clearing an equation of fractions (multiplication); and finding the value of $x$ from an equation of the type $4x = 17$ (division). Hence it appears that the fundamental types of exercises are to be identified by analyzing the solutions of equations. But this principle has not been accepted by most test-makers in the field of algebra[1] and consequently the available measuring instruments appear to be less satisfactory than the corresponding ones in arithmetic.

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[1] See page 487.

[2] See pages 303-4; 468-69.

The measurement of ability to solve verbal problems in algebra is similar to the measurement of the corresponding phase of arithmetic, and the construction of suitable instruments is dependent upon identifying the important types of problems.[2]

## II. GEOMETRY

**The nature of geometry.**—Geometry differs from arithmetic and algebra in certain significant respects. There is no manipulation of symbols—a prominent phase of both arithmetic and algebra. Although the development of geometry may be traced back to a practical need arising among the Egyptians to survey their lands after the frequent overflowing of the Nile, geometry itself was developed by the Greeks as an abstract subject, and to-day is generally described as the "science of space relationships."[3] Before the child begins the study of geometry in the secondary school, he has measured distances and learned to calculate areas and volumes; but these practical achievements are negligible assets in the study of a science that starts "from certain definitions, axioms, and postulates."[4] In contrast, arithmetic and the elementary algebra taught in the secondary school are "practical" subjects. It is true that both of these subjects involve scientific phases, but the pupil studies them primarily as arts of manipulating symbols according to certain rules.

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[1] For a description of one series of tests based on this principle see MONROE, WALTER S., DEVOSS, J. C., and KELLY, F. J.—*Educational Tests and Measurements, Revised and Enlarged Edition.* Boston: Houghton Mifflin Company, 1924, p. 305. A number of other tests are also described in this reference.

[2] See pages 514-15.

[3] "——— geometry is the science of certain abstractions which the mind makes concerning form." SMITH, D. E.—*The Teaching of Elementary Mathematics.* New York: The Macmillan Company, 1900, p. 235.

[4] SMITH, *op. cit.*, p. 257.

In arithmetic and algebra most of the needed definitions can be evolved from experience, and, in general, highly precise and exact formulations are not required; but when a definition is "a controlling factor in several logical demonstrations" exactness is demanded. For example, a student probably "knows" what a right angle is before he begins the formal study of plane geometry, but he finds that this definition is now unsatisfactory. Similarly he probably has a definition for a straight line but finds that he must learn another one, and furthermore that a statement in his own words, which probably expresses the idea of a straight line clearly to him, is not acceptable.

Geometry probably seems a queer subject to most high-school students. Many of the concepts seem to be contrary to experience, and some of the theorems appear to be foolish. For example, the student is told the line he draws is not a real line because a true line has neither breadth nor thickness. In the study of mensuration in arithmetic, he learned that a right angle is one of 90°; in geometry he is asked to prove that all right angles are equal.

**The nature of achievement in geometry.**—The preceding description of geometry has implied something of the nature of achievement in this field. The student is expected to become able to reproduce the demonstrations of theorems given in the text or developed in the classroom and to do original exercises. This statement, however, is general, and the ability designated includes a number of specific elements. The student must learn precise meanings for a number of technical terms—such as isosceles triangle, perpendicular, bisect, equilateral, arc, chord, congruent, median, and the like. He must also learn to recognize geometrical figures, to draw them upon request, and to perform with ruler and compass such constructions as bisecting a given angle, or constructing a triangle when given one side and the adjacent angles. He is expected to learn to read and use a limited number of symbols commonly used in geometry—such as $\angle ABD$, $\perp$, $BC = EF$, and the like. Finally he must be able to recall and state accurately the axioms, postulates, and basal theorems of geometry when they are needed in a demonstration.[1]

**Abstraction required in geometry.**—In dealing with lines, angles, triangles, and the like, the student of geometry is required to neglect the color, size, and certain other qualities of geometrical figures, and to give attention to only the characteristics specified by the theorem. He finds that for certain purposes a circle with a radius of one inch may be considered identical with a circle having a radius of five inches or five miles. The mental process of abstracting certain elements from experience and thinking about them apart from other elements represents a high degree of intellectual maturity. It is beyond the ability of the average tenth-grade student; and consequently he substitutes memorization of demonstrations for reflective thinking.

**Tracing logical thinking in studying geometry.**—A prominent type of learning exercise in geometry is to request the student to trace the logical thinking[2] of the demonstration of a theorem. In order to be effective, this activity cannot be passive. The student must think reflectively. The usual test of his achievement is a request to reproduce the demonstration, and the student soon discovers that the reproduction must be essentially verbatim. Consequently his study is likely to become memorizing rather than real tracing of the thinking.

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[1] For a list of fundamental theorems and constructions see the report of the National Committee on Mathematical Requirements. "The Reorganization of Mathematics in Secondary Education," The Mathematical Association of America, Inc., 1923, pp. 57–60.

[2] See pages 212-13 for an exposition of this type of learning activity.

**Doing original exercises.**—In an original exercise the student is asked to work out the demonstration. This requires that he analyze the theorem. The analysis involves drawing an appropriate figure and stating what is given and what is to be proved in terms of the figure. He must then recall the definitions, axioms, postulates, and theorems (previously demonstrated) that are essential in formulating a logical demonstration.[1] Apparently it is assumed that the study of the demonstrations given in the text will equip students for doing original exercises, but in fact the two types of learning activity have little in common, especially when the study of demonstrations degenerates into memorization. Consequently the teacher should recognize that students need training in doing original exercises. The fact that students generally consider such exercises difficult is probably not so much an indication of the inherent difficulty of the exercises as the failure of teachers to provide appropriate training in the method of attacking original exercises.

In an experimental investigation to determine the effect of certain training, Perry[2] formulated a list of twelve questions and statements. These were mimeographed and placed in the hands of the students of the experimental group, who were asked to follow the indicated procedure in "attacking either propositions or exercises." The results of the investigation indicated that this instructional technique was "markedly helpful to the group of average students, of slight benefit to the group of superior students, and detrimental to the group of very superior students in initiating and developing the habits of analyses and generalizations necessary for successful solutions of these 'originals.'"[1]

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[1] For a more elaborate description of the process of doing original exercises, see Touton, F. C.—"Solving Geometric Originals," *Teachers College, Columbia University Contributions to Education*, No. 146. New York: Bureau of Publications, Teachers College, Columbia University, 1924, pp. 66–82.

[2] Perry, W. M.—"A Study in the Psychology of Learning in Geometry," *Teachers College, Columbia University Contributions to Education*, No. 179. New York: Bureau of Publications, Teachers College, Columbia University, 1925. 59 pp.

**The study of geometry as a means of training in reflective thinking.**—Since the demonstration of a geometrical theorem affords an obvious illustration of systematic and precise reasoning, it may appear that the study of geometry should be highly effective as a means of developing skill in reflective thinking. Inquiry into this function of geometry belongs under the topic of "transfer of training,"[2] but it will not be inappropriate to note that the reflective thinking in geometry differs in certain respects from that which occurs in non-mathematical fields. Probably the most significant difference is the fact that the proof of a geometrical theorem is arranged in syllogistic form, explicit and indisputable reasons being given for each step. In contrast, the reasoning about a thought question in history appears crude and unsystematic. In view of the differences between reflective thinking in geometry and that which occurs in non-mathematical fields, it is not surprising that the study of geometry does not appear to be effective as a means of training pupils to reason.

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[1] PERRY, *op. cit.*, p. 36.

[2] See page 246.

**Relation of the divisions of elementary mathematics.**—The reader who has studied the preceding discussions of the psychology of arithmetic, algebra, and geometry has probably noted certain similarities as well as certain differences in these divisions of elementary mathematics. In spite of the fact that these subjects have certain methods of reasoning and other items in common, they were developed independently, and until recently have been taught as separate subjects in our schools. For several years some authorities have urged that algebra and geometry, together with portions of other divisions of mathematics, be fused into a unified course. When the common elements and relationships between other phases are noted, there seem to be strong reasons for such a reorganization of the curriculum in elementary mathematics. Judd states that superior results are secured from a unified course, and offers the explanation that the "combination contributes to the training of pupils in generalization."[1]

**Difficulties in measurement of achievement in geometry.**—The measurement of achievement in geometry, as in other subjects, is dependent upon securing from pupils performances that are dependable evidence of their achievements, and that can be conveniently described in quantitative terms. This is more difficult to do in geometry than in either arithmetic or algebra. In both of these subjects the test exercises are small enough to permit of a considerable number being done within a few minutes. By marking each exercise as either "right" or "wrong," a pupil's total performance can be described in terms of the "number attempted" and the "number right." But considerable time is required to write the demonstration of a theorem even when the pupil understands clearly just what each of the steps is. When it is necessary for him to reason out the demonstration a longer time is required. Consequently, a pupil could not be expected to give more than three or four demonstrations within a class period. Such a performance is difficult to describe satisfactorily. For obvious reasons it is not satisfactory to mark each demonstration as either "right" or "wrong," and it is difficult to devise an objective method for giving partial credit for demonstrations partially right.

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[1] Judd, C. H.—*Psychology of Secondary Education.* Boston: Ginn and Company, 1927, p. 99.

Several ingenious types of exercises have been devised by test-makers[1] to overcome the difficulty described in the preceding paragraph. There is, however, a more fundamental difficulty in measuring achievement in geometry. The description of the nature of ability in geometry[2] indicates that the real test of a pupil's achievement is afforded by his response to "original" exercises, or at least to exercises for which he does not have a ready-made answer.[3] If he merely gives a memorized response, the performance is not dependable evidence of his achievement. It is seldom possible to determine definitely whether the demonstration given represents memory or reasoning.

## III. English Composition

Although English composition is listed here as a high-school subject, this discussion is not limited to that level.

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[1] For a description of typical geometry tests see Smith, H. L., and Wright, W. W.—*Tests and Measurements.* New York: Silver, Burdett and Company, 1928, pp. 120–30.

[2] See page 519.

[3] For the justification of this statement see pages 307f.

It might be assumed that in a subject which a child begins to learn almost in infancy, and in which he is constantly, day by day, and year by year, acquiring new experience, a degree of proficiency would be attained that on the high-school level would render the English teacher's task an easy one. It is very doubtful, however, if this is true. The teacher of high-school English only too often finds himself confronted with the same problems that trouble teachers in the grades—with the problems incident to a constant battle against faulty habits of thought and of expression, and with the lack of ideas, the lack of ability to organize ideas, and the lack of accurate habits of expression.

**The nature of ability in English composition.**—Ability in English composition is commonly thought of primarily in terms of the grammatical and rhetorical accuracy of the sentences and paragraphs written or spoken. The words and phrases used, their organization into sentences and paragraphs, punctuation, capitalization, and the like merely make up the *form* of language. The ideas that are expressed represent another phase, which is commonly designated as the *content* of language. Hence ability in English composition may be described as the ability to *think* appropriate ideas relative to the topic under consideration plus the ability to *express* these ideas effectively and in correct form.

In this statement there is no intentional implication that the content of language can be separated from its form. One may repeat sounds or write words that he has memorized but such activities do not qualify as language. On the other hand, one cannot formulate ideas, except very simple and concrete ones, without employing language symbols. Hence the content of language cannot be separated from its form. One does not formulate ideas independently of language symbols and then translate them into words. The distinction, however, will facilitate the consideration of the learning process in English composition.

The intimate relation between the content and the form of language does not appear to be generally recognized, at least in practice. Some of the learning exercises commonly employed in composition classes suggest the belief that form may be separated from content, at least for instructional purposes. In measuring achievement, form is commonly emphasized because it may be rated somewhat objectively, while the evaluation of content must be highly subjective. Pupils imply the belief that content is not intimately connected with form when they insist that they know the answer to a question but cannot tell it. Usually a pupil who experiences difficulty in telling what he thinks he knows has only hazy and unorganized ideas to express. In general a teacher is justified in maintaining that a pupil does not know what he cannot tell.[1] It is of course true that a pupil who has reasonably definite and well-organized ideas may fail to express them in a way that is considered grammatically and rhetorically correct. He may even fail to express them so that his words are correctly and accurately understood by his audience, but if he has clear ideas they have some form.

**The objectives of English composition.**—The definition of ability in English composition suggests two general objectives—ideas and the ability to express them clearly, forcefully, and accurately. The particular goals to be attained under each of these heads cannot be specified. The pupil should acquire the ideas essential for effective thinking, speaking, and writing about his environment and the various phases of his personal, social, and economic life. Such an objective, however, includes much that is commonly assigned to other divisions of the curriculum, and any attempt to specify the ideas for which English composition should assume responsibility would meet the approval of few if any authorities in this field. Under form there are a number of obvious objectives such as ability to spell correctly the words used in writing, ability to determine when to use each of the various punctuation marks, and ability to avoid incorrect usage of such words as *that*, *which*, *from*, *as*, *but*, *however*, and *if*, but there is no agreement in regard to a complete list of objectives.

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[1] It is assumed that the pupil is attempting to use his mother tongue and not a foreign language.

**How one learns ideas to express.**—The ideas that come into a person's consciousness in response to a stimulus, such as a question or a request that he speak or write upon a given topic, depend upon the ideas he has already acquired and the associations he has formed with these ideas. The richer his previous experience has been, and the greater the number of S→R bonds, the more copious and effective the flow of associations will be. Most of the types of learning activity listed on pages 200-01 contribute to a pupil's preparation for expression. Some perceptual experiencing is essential, and vicarious experiencing is a very fruitful source of ideas; but in order that a student be able to think of the right ideas to express, he must build up such associations that a topic or question will arouse the ideas pertaining to them. There is need, then, for him to think about his experiences. Tracing the thinking of another person and comprehending generalizations also contribute to the student's preparation. When he expresses the ideas he has acquired, he strengthens the S→R bonds they represent and probably initiates new connections between them.[1] Therefore a pupil's learning in the other subjects he studies and in his out-of-school activities contribute to the content of his language. In general the pupil who lacks ideas to express either is lacking in experience or has never learned to associate his experiences with his composition work. Frequently, for such a pupil, the teacher must provide experience, either actual or vicarious, and by individual attention and careful questioning help him build up the necessary associations. Teachers can aid pupils by providing them with opportunities in the composition class to utilize previous experiences as a basis for compositions.

Learning a vocabulary is essentially included in the learning of ideas, and the size of a pupil's writing vocabulary is an index of his stock of ideas. It should be noted, however, that the meaning associated with a word may vary from a hazy and indefinite one to one that is very definite and precise. At first the learner's meanings are usually vague and general, and it is necessary that he continue his learning until he builds up meanings sufficiently definite and precise for his needs. When terms are used "with intentional exactness so as to express a meaning, the whole meaning, and only the meaning," they become technical.[2] For some purposes the student must continue his learning of meanings to the technical level.

O'Brien[3] has reported a study which affords some indication of the status of the writing vocabulary of high-school students. Slightly more than eighteen hundred students in grades seven to twelve wrote during a twenty-five-minute period a composition on either "How I would most enjoy spending next Christmas vacation" or "What I would like to do next Saturday to have a good time." An analysis of these compositions showed that nearly ninety per cent of the words used are in the first thousand of the Thorndike list. Furthermore, the words used in a particular composition included practically no abstract terms, and a group of compositions "with a median length of 125 words" contained an average of only four or five descriptive or definitive adjectives. A similar study[1] of compositions written by college students shows "an appalling paucity of expression" even in the cases of upperclassmen.

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[1] See the discussion of expression as a learning activity on pages 213f.

[2] Dewey, John.—*How We Think.* Boston: D. C. Heath and Company, 1910, p. 184.

[3] O'Brien, F. P.—"The Vocabulary of High-School Pupils in Written Composition," *Journal of Educational Research*, 11: 344–50, May, 1925.

**Organization of ideas a type of reflective thinking.**—In thinking about a topic many ideas may come into the mind of the speaker or writer. Some are pertinent to the topic; others are not. If extraneous ideas are introduced into the discussion, attention is likely to be distracted from the main issue. The good speaker or writer carefully evaluates the ideas that occur to him and utilizes only those which in his judgment will be helpful to his audience in connection with the particular topic being considered. The good speaker or writer, furthermore, evaluates those ideas which he judges pertinent to his problem and assigns those of minor importance to subordinate positions.

It is not sufficient to reject only those ideas which are erroneous or unimportant in general. An idea may be very useful in connection with one topic but have little or no value in the treatment of another. Good speaking or writing is not merely the expression of good ideas. It is rather the expression of ideas that are good for a particular purpose. One of the difficult tasks of a speaker or writer is to stick to his text. His prejudices in favor of certain ideas constantly tempt him to introduce topics that have little or no connection with his present purpose.

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[1] WITTY, P. A., and FRY, MABEL.—"The Vocabulary Content of Compositions Written by College Students," *Journal of Educational Research*, 19: 135–38, February, 1929.

The extent of selection and organization necessary to preserve continuity of discourse differs with the type of verbal expression. In conversation, where the stimulus to speech is constantly repeated, comparatively little selection and organization are possible. In oral composition, both selection and arrangement are important, and the speaker's problem is complicated by the necessity for instant clearness, and, sometimes, by the response or lack of response of the audience. In writing, selection and arrangement may be arrived at by a more leisurely process.[1] Most good writing is a result of many revisions. Sentences or even whole paragraphs which have been written at the expense of much effort are eliminated and others added. Sometimes a slight modification of an idea or the way in which it is presented will greatly increase its effectiveness. The choice of suitable words for the expression of ideas is necessarily a part of the process of selection and arrangement. The pupil with a rich fund of associated ideas and hence a large working vocabulary will obviously have a wider range of choice and will express himself more effectively than his less fortunate neighbor.

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[1] See Starch, Daniel.—*Educational Psychology.* New York: The Macmillan Company, 1919, p. 429.

**Learning the form of language.**—The form of the English language is relatively simple when compared with that of Latin and some other foreign languages, but it is an elaborate system of conventionalities. For example, verbs are required to agree with their subjects in number and person. In general, conformity to this rule aids in accuracy of expression, but the use of a singular verb with a plural subject does not necessarily mean that the writer's ideas are not clearly and concisely defined or that the reader will experience difficulty in understanding what has been written.

Much of the child's learning of the form of language is accomplished by imitation. He tends to use those forms which his experience shows to be effective as a means of communication. The fact that conformity with the rules of grammar and rhetoric is not necessary for effective communication, especially when the audience is accustomed to the form of language used, makes it inevitable that much of the form the pupil imitates either consciously or unconsciously will be faulty. By the time the child has entered school, he has already formed many habits of speech. Through imitation of older members of his household, or of other children met in play, he may have fallen into such errors as "I seen him," "I had went," "it ain't," "it is me," etc. In spite of correction by the teacher in the elementary school, these bad habits of speech may persist, and be manifest even after the child enters the high school. This condition obviously complicates the task of teaching English composition. Habits already formed must be broken and new ones engendered in their place. Too frequently it happens that the mental responses have become so strong, so fixed, that the efforts of the school to effect new and correct responses fail to function.

The substitution of accurate for inaccurate responses requires a large part of the teacher's effort. Something of the magnitude of a teacher's task in training students in the form of English composition is indicated by the persistence of errors in their written and oral language.[1] In view of the general nature of learning curves[2] one would expect language errors to be much less frequent in the high school and college than in the elementary school. There is some decrease, but the amount is probably less than a person would expect, and those "language items which cause pupils the greatest difficulty are usually the items which persist."[3] This condition suggests that the instructional procedures now employed in teaching language are lacking in effectiveness.

It might perhaps be inferred that, inasmuch as wrong habits have become fixed through a process of imitation, they can be broken down and new correct habits engendered by imitation of correct usage. But new attitudes must be stimulated at this stage in the pupil's education. Earlier in life he imitated unconsciously. Now he must be taught to imitate consciously, and to imitate only the correct forms. Thus not only imitative powers, but self-criticism and volition must be brought into play. Needless to say, this effort can be prompted only by powerful incentive. The teacher's task, therefore, is more to stimulate this desire than to teach correct forms.

Our schools have realized the *need* of instruction in language. More time is given to it and the allied subjects than to any other subject in the school curriculum. In the effort to secure good form, various types of learning exercises are used: requests to study and memorize rules, to correct sentences, to study good writings with reference to form, to write compositions, and the like. Responses to such exercises may contribute to the acquisition of controls of conduct that function when the pupil attempts to express his ideas, but it is generally agreed that memorizing rules, correcting sentences, and doing other formal exercises are not very effective learning activities. Consequently, our schools have come to emphasize expression, both oral and written, as a means of language training. A justification of this practice is afforded by the intimate relation between the form and the content of language. Training in form apart from content cannot be relied upon to produce controls of conduct that will function when the pupil engages in formulating and expressing ideas.

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[1] For a summary of studies see LYMAN, R. L.—"Summary of Investigations Relating to Grammar, Language, and Composition," *Supplementary Educational Monographs*, No. 36. Chicago: University of Chicago, 1929, pp. 82–124.

[2] See pages 174f.

[3] LYMAN, *op. cit.*, p. 132.

The situation appears to be different from that which prevails in arithmetic. In this subject we have calculation (manipulation of number symbols) and the solving of problems. Calculation is a means of solving problems, but formal exercises in calculation appear to be highly efficient bases for acquiring the controls of conduct necessary for rapid and accurate manipulation of number symbols. In other words, it appears that for instructional purposes the "form" of arithmetic may be separated from its "content." The explanation is that in solving a problem, after a person decides upon the operations to be performed, he may forget the problem temporarily while he makes the necessary calculations. There is not the intimate relation between calculation and problem-solving that exists between form and content of language.

The importance of obtaining the coöperation of other departments must not be overlooked in the teaching of English composition. If pupils are allowed to use ineffective and inaccurate language in all their other activities, it cannot be expected that they will habitually speak and write forcefully and correctly in the English classroom.

**Natural versus artificial language situations.**—The primary function of language is communication for the purpose of influencing the actions, thinking, or emotions of other persons. A secondary use, but a very important one, is as a means of entering into "more intimate sociable relations with them."[1] This function is emphasized by Judd[2] who calls language "the fundamental institution" of social life. A group of persons cannot become a social unit unless they have an effective means of communication. Hence a natural language situation is one in which a person wishes to influence the action, thinking, or emotions of other persons or to enter into "more intimate sociable relations with them." Language activity is the natural response to such situations, and consequently it is most effectively stimulated by creating a situation in which a student has something to say and faces an interested audience.

Unfortunately, since natural language situations are difficult to create in the schoolroom, teachers resort to artificial stimuli. Consequently, much of the language activity of students tends to degenerate into manipulating language symbols (words and phrases) in conformity with a complex set of rules. A student required to write a theme on a topic in which he is not interested proceeds to set down sentences that "sound well," or consults an encyclopedia or other source, and "copies," usually with only minor modifications, what he reads. Such activity makes relatively slight contributions to the acquisition of real language ability. Dewey points out that in comparison with the ability to repeat catch phrases, cant terms, and familiar propositions, "genuine ignorance is more profitable."[1] Such exercises in composition must be ineffective, because they fail to draw on the pupil's own fund of interests and experiences, and, therefore, fail to start in its full volume the flow of association that we call thinking. When the pupil is not interested, or when his experience is inadequate to furnish the necessary ideas, his thinking is without richness, and his ability to express is consequently small.

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[1] Dewey, John.—*How We Think.* Boston: D. C. Heath and Company, 1910, p. 179.

[2] Judd, C. H.—*The Psychology of Social Institutions.* New York: The Macmillan Company, 1926, Chapter X.

**Relative importance of oral and written composition.**—Since the out-of-school language activity of most persons is predominantly oral, the argument has been advanced that oral composition rather than written should be the mode of instruction in school. Although much has been said on both sides of this question, Lyman[2] reports that there has been only one investigation planned to determine the relative merits of the two types of language instruction. This investigation,[3] which was confined to the ninth grade and included classes in nineteen high schools in Illinois, indicated that instruction in oral composition was more effective than in written. Unless we can believe in the transfer of training from written to oral speech, it seems reasonable to suppose that these results are significant, and that oral English should receive at least as much attention in the schools as does written English.

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[1] Dewey, John.—*How We Think.* Boston: D. C. Heath and Company, 1910, p. 177.

[2] Lyman, R. L.—"Summary of Investigations Relating to Grammar, Language, and Composition," *Supplementary Educational Monographs,* No. 36. Chicago: University of Chicago, 1929, p. 65.

[3] Clapp, John M.—"Report of the Experiment in English Composition," Proceedings of the High-School Conference, November 20, 21, 22, 1913. *University of Illinois Bulletin,* Vol. XI, No. 17. Urbana, Illinois: University of Illinois, 1913, pp. 148–61.

**The measurement of ability in English composition.**—The measurement of English composition requires an evaluation of both content and form. The content of a written composition is a subtle characteristic. It depends upon the vividness of expression, the organization of ideas, and the wealth of associations that give the central ideas their setting. These features of content are expressed through the choice of words and the structure of sentences and paragraphs. Content and form are so intimately connected that, aside from the items of form that are specified by the rules of grammar, any attempt to measure one is made difficult by the presence of the other. If a person attempts to evaluate a composition for content, he finds it difficult if not impossible to neglect such items of form as diction, sentence structure, paragraph structure, and the like. The evaluation of most of the items of form may be separated from the content, but a relationship still exists, and should not be ignored. Poor paragraph organization, evidenced generally by lack of continuity in the ideas expressed in consecutive sentences, is in part due to poor content, i.e., lack of clear thinking, and in part to a lack of skill in language form.

Numerous composition scales have been devised for the purpose of measuring the "general merit" of written compositions. Such a scale consists of a series of suitable compositions arranged in ascending order of merit.[1]

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[1] For a description of composition scales and a summary of published criticisms see LYMAN, R. L.—"Summary of Investigations Relating to Grammar, Lan-

Such an instrument is similar to a handwriting scale[1] and is to be used in the same way. The results of measurement of achievement in written composition, however, are far from satisfactory. The specimens that make up a handwriting scale may consist of the same sentences, and the pupils whose handwriting is being measured may be required to write these sentences. But the compositions comprising a language scale will necessarily differ in content even if written on a single topic, and unless the use of the scale is restricted, the teacher faces the task of matching compositions on a variety of topics with those that make up the scale.

A large number of tests have been devised for measuring phases of the form of language.[2] The most common type of test exercise is a sentence that involves an error. The pupil is to identify the error and correct it. There are several variations of this general type, a popular one being to give two forms of a word or phrase, one correct and the other incorrect. Lyman[3] has pointed out that this testing procedure implies the assumption that "ability to distinguish between right and wrong language forms and to correct the latter indicates that the pupil actually uses language forms correctly in his own speech and writing." After reviewing the experimental evidence relative to this assumption this writer labels it as "highly questionable."

**Relation of language ability to general intelligence.**—The correlation between the general merit of written compositions and scores on intelligence tests appears to be .70

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guage, and Composition," *Supplementary Educational Monographs*, No. 36. Chicago: University of Chicago, 1929, pp. 134–57.

[1] See pages 438–39.

[2] For a brief description see Lyman, *op. cit.*, pp. 111f.

[3] *Ibid.*, p. 124.

or higher.[1] Hence, a teacher may expect measures of language ability to agree rather closely with the I.Q.'s of pupils. This close relationship also means that measures of language ability indicate the relative intelligence of the members of a class.

## IV. The Natural Sciences

**The nature of ability in science.**—Ability in a science such as botany or physics includes knowledge and the general pattern of conduct commonly designated as a scientific attitude. The knowledge includes specific facts, such as the boiling point of water on the Centigrade scale or the number of petals in a certain flower; concepts, such as those represented by technical terms like germinate, life cycle, evaporate, resistance, or refraction; and principles such as the Law of Falling Bodies. A person who has acquired the scientific attitude,[2]

I. Believes in universal cause and effect relations and understands the general principles relating to collecting data, their interpretation, and the validation of tentative conclusions.
II. Possesses a sensitive curiosity concerning reasons for phenomena or the consequences of certain conditions.
III. Derives satisfaction from
    a. Systematic and careful search for data, even when it is prolonged and difficulties are encountered.
    b. Testing data with reference to pertinence, validity, accuracy, and adequacy.

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[1] Lyman, R. L.—"Summary of Investigations Relating to Grammar, Language, and Composition," *Supplementary Educational Monographs*, No. 36. Chicago: University of Chicago, 1929, p. 175.

[2] See Curtis, F. D.—"Some Values Derived from Extensive Reading of General Science," *Teachers College, Columbia University Contributions to Education*, No. 163. New York: Bureau of Publications, Teachers College, Columbia University, 1924, p. 48.

c. Suspending judgment until sufficient evidence is secured.

IV. Is annoyed[1] by superstitious beliefs such as "signs," "good or bad luck," "unexplainable mysteries" or any other noncomformities to the principles of scientific procedure.

Writers frequently list other abilities that are expected to result from the study of the natural sciences. These include "ability to observe," "an interest in science," and "skills in manipulating apparatus." It is probably true, however, that most, if not all, authorities would agree that knowledge, sometimes described as "useful information," and a scientific attitude are the most important phases of ability in the natural sciences.

**Perceptual experiencing, a learning activity in the natural sciences.**—When compared with the learning processes in the school subjects considered in the preceding pages, those in the natural sciences are distinguished by the prominence of perceptual experiencing. This is attested by the provisions for laboratory work to supplement the child's perceptual experiencing outside of school. As pointed out on pages 205f., a foundation of perceptual experience is essential for other learning activities, but science teachers and school administrators are asking how much individual laboratory work is necessary for efficient learning in the several sciences. In listening to and observing a demonstration lecture the pupil engages in a type of perceptual experiencing in addition to tracing the thinking of the lecturer and comprehending the products of his thinking. He may experience vicariously by reading his textbook. If the student has an adequate foundation of direct perceptual experience, observing demonstrations by the teacher may be a highly efficient learning activity. This statement is supported by experimental evidence. After reviewing reports of eight investigations relating to the teaching of science on the high-school level, Downing[1] states: "The lecture-demonstration method of instruction yields better results than the laboratory method in imparting essential knowledge, and is more economical of time and expense. This is true for both bright and dull pupils and for all types of experiments. The lecture-demonstration method appears to be the better method for imparting skill in laboratory technique in its initial stages and for developing ability to solve new problems."[2] However, the reader should note that in order to be efficient as a learning activity, observing must be active and not passive. In observing, the student should have a purpose; he should know what to look for and then direct his attention to those phases of the object or event. Frequently observation must be analytic.

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[1] It is implied that the person is sensitive to violation of scientific procedure.

**Learning to observe.**—Perceptual experiencing, especially visual, involves more than the mere functioning of sense organs. In order that visual experiencing may be educationally efficient, the pupil must see the right things—that is, he must discriminate and focus his attention upon the significant features of the object or environment being observed. The difference between a trained observer and one who is untrained becomes apparent on a field trip. The latter may be interested and may try to observe, but he will see much less than the trained observer. We describe the untrained observer's handicap by saying he does not know what to look for. He also does not know the significance of what he does see.

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[1] Downing, E. R.—"A Comparison of the Lecture-Demonstration and the Laboratory Methods of Instruction in Science," *School Review*, 33:688–97, November, 1925. See also Thorndike, E. L.—*Education*. New York: The Macmillan Company, 1912, p. 178.

[2] A similar conclusion is reported by Anibel, F. G.—"Comparative Effectiveness of the Lecture-Demonstration and the Individual Laboratory Method," *Journal of Educational Research*, 13:355–65, May, 1926.

The faculty psychologists recognized observation as one of the faculties of the mind,[1] and a number of authorities claimed that the sciences, especially botany, were effective means for training the faculty of observation. Although we do not now accept faculty psychology and the doctrine of formal discipline, it is obvious that an important phase of the pupil's learning in a science is, or at least should be, learning to observe in the field being studied. There may be some "transfer"[2] to other fields, but the pupil cannot become an efficient learner in a science until he has learned to observe in that field.

**Analysis, comparison, abstraction, and generalization.**—Although a foundation of experiencing, perceptual and vicarious, is essential, learning in the sciences involves other activities. We designate one of these activities by saying that the pupil needs to think about what he observes. Isolated experiences can contribute very little to his education. In order to get the most out of them, the pupil must analyze and compare his experiences, identifying the significant elements. These processes should be followed by abstraction and generalization in which general concepts and principles or laws are formulated. In botany, for example, plants possessing similar characteristics are classified under such names as fungi, trees, conifers, grasses, and the like. The parts of flowers are classified as petals, sepals, stamen, and pistils. Life processes are identified and designated as fertilization, osmosis, digestion, respiration, etc. In physics the pupil is expected to develop such concepts as gravity, acceleration, velocity, boiling point, evaporation, expansion, and the like.

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[1] See page 5.

[2] See Chapter VII for the discussion of transfer of training. Starch (*Educational Psychology*, Revised Edition, pp. 286f.) describes an experiment by Hewins in which the conclusion was reached that considerable transfer resulted from specific training in observation in botany. After making some additional computations, Starch expresses the conviction that the transfer was less than the author believed it to be.

These processes of analysis, comparison, abstraction, and generalization—all required in the sciences—are difficult for the immature learner. In supporting this thesis Judd[1] calls attention to the erroneous generalizations made by primitive peoples and even by uneducated people to-day. "The common man has complete confidence in the testimony of his senses," but things are not always what they seem. For a long time the earth "appeared" to be flat. In order to secure the evidence of its spherical shape it is necessary to disregard certain experiences and to select those that are truly indicative of the shape of the earth. Similarly until the time of Galileo people believed that the rates of falling bodies were in proportion to their weight. This generalization appeared to be in agreement with their experiences. A feather fluttered down slowly but a coin or stone fell rapidly. They, however, failed to analyze and compare their experiences accurately in effecting a generalization.

The process of abstracting is especially difficult for the elementary-school pupil or even for one who is enrolled in the junior high school. For example, he does not experience gravity—merely its effect. To him the weight of an object is a property that the object possesses rather than the effect of gravity. When he is told that the Law of Gravitation is universal and hence that any two objects attract each other, he finds nothing in his experience to corroborate this generalization. In other words, the analysis, comparison, abstraction, and generalization required to produce many of the abstract generalizations of science are beyond the capacity of pupils below the senior-high-school level and even in this division of our school system these processes are not easy.

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[1] JUDD, C. H.—*Psychology of Secondary Education.* Boston: Ginn and Company, 1927, pp. 327f.

The thought processes described in the preceding paragraphs are commonly designated as induction, i. e., thinking from particulars to generalizations. Dewey[1] analyzes "scientific induction" into "(1) elimination by analysis of what is likely to be misleading and irrelevant, (2) emphasis of the important by collection and comparison of cases, (3) deliberate construction of data by experimental variation." He points out, however, that the building up of ideas (inductive discovery) is followed by "developing, applying, and testing" (deductive proof). Hence it is more appropriate to call the mental process which results in generalizations and abstractions *inductive-deductive* than to use the single term *inductive.*

**Comprehending the products of abstraction and generalization.**—Fortunately it is unnecessary for the pupil to discover and develop all of the generalizations of science. Instead he may comprehend the tested and systematized generalizations evolved by trained thinkers in the several fields. The pupil may do this, but the activity is not easy. A generalization is expressed in word symbols, and in comprehending the generalization the pupil must build up and associate with these symbols the ideas that the writer or speaker associated with them. Even when guided by an explanation and by illustrations, the pupil may find this task a difficult one. Unfortunately science textbooks are made up largely of statements of generalizations, that is, the products of the thinking of scientists. Frequently there is too little explanation and illustration. The pupil encounters a relatively large technical vocabulary, much of which is new to him. One investigator[1] reports the following numbers of words considered "difficult" for high-school pupils:

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[1] DEWEY, JOHN.—*How We Think.* Boston: D. C. Heath and Company, 1910, p. 86.

| | ESSENTIAL WORDS | ACCESSORY WORDS | TOTAL |
|---|---|---|---|
| Common science vocabulary[2] | 191 | 24 | 215 |
| General science | 916 | 648 | 1564 |
| Biology | 675 | 677 | 1352 |
| Chemistry | 765 | 488 | 1253 |
| Physics | 709 | 331 | 1040 |

The situation is further complicated by the fact that ability to write or speak statements is commonly accepted by both teacher and pupil as evidence of understanding the verbal symbols used. It is obvious, however, that the pupil may learn to repeat words and phrases without learning their meaning. In fact, he may become relatively skillful in using certain verbal symbols without associating much, if any, meaning with them. Hence many pupils who find comprehending the products of abstraction and generalization difficult, memorize the verbal symbols. They, of course, are engaged in a sort of learning activity while doing this, but it is very different from comprehending the products of abstraction and generalization. Judd[1] calls attention to "three types of mental activity which can be induced by reading a statement of a scientific principle." In the first there is the act of memorizing the words of the statement without any real comprehension of them. In the second there is comprehension to a limited degree. In the third the pupil may use "the statement as a guide in his thinking."

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[1] PRESSEY, L. C.—"The Determination of the Technical Vocabulary of the School Subjects," *School and Society*, 20:91–96, July 19, 1924. Additional evidence of the vocabulary difficulties that high-school students encounter is supplied by the following references: POWERS, S. R.—"The Vocabularies of High-School Science Text-books," *Teachers College Record*, 26:368–82, January, 1925. POWERS, S. R.—"A Vocabulary of Scientific Terms for High-School Students," *Teachers College Record*, 28:220–45, November, 1926.

In the second of these articles a list of 1,828 "important" words is given.

[2] "Common science vocabulary" includes words common to two or more divisions of science.

**Solving problems.**—Solving problems, both verbal and those growing out of laboratory work, is a prominent learning activity in physics and chemistry. A similar activity, although not commonly designated by this name, occurs in answering thought questions in all the sciences. The discussion here is limited to the solving of problems that includes mathematical calculations.

Consider the verbal problem: "How deep is a mine shaft if a stone is heard to strike the bottom six seconds after it is dropped?" In solving this problem, the student must first read it and identify the quantities involved. These are: (1) depth of mine or distance the stone fell;[2] (2) force of gravity; (3) rate at which sound travels; (4) number of seconds during which the stone was falling;

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[1] JUDD, *op. cit.*, p. 337.

[2] This is also the distance the sound traveled.

(5) number of seconds the sound was traveling from the bottom of the shaft to the observer; (6) total elapsed time. Next the student must recall or obtain from some source the relationships that exist among the quantities listed. With these general relationships in mind he is ready to formulate statements of the relationship between the particular quantities in this problem. In doing this he usually represents those unknown by convenient symbols. For example, $t_1$ may be used to represent the number of seconds during which the stone was falling; $t_2$, the number of seconds the sound was traveling from the bottom of the shaft to the observer; $g$, the force of gravity; $s$, the rate at which sound travels; $d$, the depth of the shaft in feet. He may then state the relationships between the quantities of this problem:

$$t_1 + t_2 = 6$$
$$d = \frac{1}{2} g \, t_1^2 = s \, t_2$$

The crucial phases of this reasoning process are (1) identifying the quantities in the problem; (2) recalling the general relationships or laws; (3) applying them to the problem under consideration. After the equations are stated, the student must recall, or secure from sources, the numerical value of $g$ and $s$ and then solve the equations. These steps are largely routine and should involve very little reflective thinking.

Solving a problem arising in laboratory work may be more difficult because it is not defined in terms of the particular question or questions to be answered. It may also be difficult to identify the quantities involved. The explanation of these difficulties is that the high-school student is more familiar with verbal problems than with those arising in practical situations. If his experience had been mainly with practical situations he would doubtless find the verbal problems more difficult.

**Acquiring a scientific attitude.**[1]—The mental processes involved in acquiring a general pattern of conduct are not clearly understood, but certain statements may be made which throw some light upon the process of acquiring a scientific attitude. It is sometimes stated that a general pattern of conduct is acquired as a by-product in the learning of specific habits and knowledge. This means that the acquisition of a scientific attitude occurs concomitantly with the learning of scientific facts and principles rather than as the product of an independent learning activity. It should be noted, however, that the acquisition of the scientific attitude as a by-product of performing laboratory experiments, observing demonstrations, reading accounts of scientific discoveries, solving problems, and the like, is by no means certain. Hence it is important that the teacher definitely recognize the scientific attitude as an objective and, as opportunities occur, make suggestions, ask questions, and otherwise stimulate the particular learning activities necessary for acquiring this general pattern of conduct.

Many persons acquire attitudes as a result of their associations with other persons who exhibit these general patterns of conduct. Certain teachers have become noted for inspiring their students. This means that these teachers are skillful in stimulating those mental processes that produce certain general patterns of conduct. Although it would be difficult if not impossible to specify the particular ways in which they do this, a teacher is not likely to be successful in engendering a scientific attitude if he does not consistently demonstrate that he possesses this general pattern of conduct.

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[1] For a discussion of the acquisition of general patterns of conduct see MONROE, WALTER S.—*Directing Learning in the High School.* Garden City, New York: Doubleday, Doran and Company, Inc., 1927, pp. 325f.

**Measuring achievement in the natural sciences.**—The difficulties encountered in measuring achievement in the natural sciences are implied in the preceding discussion. It is relatively easy to measure a pupil's knowledge of specific facts. It is more difficult to measure his comprehension of principles and his ability to solve problems. The measurement of attitudes and other general patterns of conduct cannot be accomplished by means of a formal test.[1]

## V. THE SOCIAL SCIENCES

**The nature of ability in the social sciences.**—When the question of the nature of ability in the social sciences is raised, one naturally thinks of memorized facts—dates, names, geographical locations, events, and the like. These outcomes of learning constitute an important phase of this ability, but there are other items that should not be overlooked. The pupil should learn generalizations,[2] acquire what Freeman calls "historical sense,"[3] and grasp the cause-and-effect relations existing among events.

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[1] See page 309 for the justification of these statements.

For a description of tests in the field of science see MONROE, WALTER S., DEVOSS, J. C., and KELLY, F. J.—*Educational Tests and Measurements*, Revised and Enlarged Edition. Boston: Houghton Mifflin Company, 1924, pp. 323–25.

[2] Dawson mentions "scientific principles of social organization" as one type of generalization. DAWSON, EDGAR.—*Teaching the Social Studies*. New York: The Macmillan Company, 1927, p. 261.

[3] FREEMAN, F. N.—*The Psychology of the Common Branches*. Boston: Houghton Mifflin Company, 1916, pp. 153f.

"Historical sense" is described as a type of imagination which in turn is defined as "merely an extension of the process which the educated adult carries on when he gains a proper degree of insight into differing points of view of other persons with whom he comes in contact."

**Reading used as a tool of learning.**—A large portion of the pupil's learning in the social sciences occurs through reading. He engages in vicarious experiencing by reading accounts of events and other activities of the past. He traces the thinking of the author who discusses events and shows the connections between them. He comprehends generalizations.

The vicarious experiencing requires a fund of basic experiences on the part of the student if he is to comprehend the printed descriptions. For example, in reading an account of colonial life in New England, the pupil is called upon to picture in his mind types of houses, articles of furniture, garments, and customs—all of which are very different from those of to-day. As a rule he will be unable to build up a true and complete mental picture, unless he has seen these things, or at least pictures of them. A bright pupil may be able to imagine colonial life from a relatively meager basis of perceptual experiences, but in general a rich foundation is required.

In tracing the thinking of the author and in comprehending generalizations the pupil encounters a vocabulary that is to some extent peculiar to the social sciences. Consequently, a phase of textbook study is the learning of new words and phrases. The meaning of some of these can be derived from the context in which they appear but frequently it will be necessary to consult a dictionary.

**The place of visual aids in teaching the social sciences.**—The need for basic perceptual experiences makes clear that visual aids have a place in teaching the social sciences. Maps, pictures, exhibits, and the like are essential, but there are differences of opinion in regard to the extensiveness of their use. With the advent of motion pictures and the development of other projection instruments, some authorities have advocated that the use of visual aids be greatly increased. Some school systems have created a department or division of visual education for the purpose of extending and systematizing the use of visual materials. It is contended that pupils learn more efficiently by "seeing" than by reading, and hence that much of the textbook study which is commonly required should be replaced by appropriate types of visual education.

After an extended investigation Freeman reached this conclusion: "The relative effectiveness of verbal instruction as contrasted with the various forms of concrete experience represented in visual education depends on two major conditions: the nature of the instruction to be given, and the character of the pupil's previous acquaintance with the objects which are dealt with in the instruction."[1] In commenting on this conclusion Freeman points out that although pictures "have a definite function to perform," the data collected in his investigation do not support the belief that they may be substituted for language. This is in agreement with the principle that efficient learning requires a "balanced" ration of learning activities. Visual education (experiencing, both perceptual and vicarious) must be supplemented by other types of learning activity.

Later Freeman[2] calls attention to the need for exercising caution in the use of motion pictures and other materials in order to avoid developing "the attitude of passive receptivity." What a child learns is the product of his own activity,[3] and although it is necessary to stimulate and direct him so that he will engage in appropriate activities, any tendency toward passivity will inevitably diminish his learning.

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[1] FREEMAN, F. N.—*Visual Education.* Chicago: University of Chicago Press, 1924, p. 69. (Reprinted by permission of the University of Chicago Press.)

[2] *Ibid.*, p. 80.

[3] See page 147.

**Dramatization as a means of learning.**—Dramatization is a form of expression and may be thought of as including the construction of models to represent machines, customs of other times, events, and the like, as well as the portrayal of historical events by acting. Dramatization in this broader sense is an effective learning activity for those who participate, especially if we include the study that must precede the actual expression.

Various forms of dramatization have been emphasized as learning activities in the elementary school. Under the direction of the teacher pupils play at keeping a grocery store, at constructing and furnishing a home, at weaving cloth on small looms, constructing a frontier fort, preparing models of ancient villages and cities, constructing miniature airplanes, and making costumes in addition to portraying historical events by acting.[1] Some of these activities, especially the portrayal of historical events by acting, are appropriate for high-school pupils. It may be noted, however, that such activities may be overdone. An elaborate historical pageant is not likely to be efficient as a learning activity.

**Memorization of facts.**—The memorization of facts has been severely criticized, but a considerable number of dates, names, events, and other facts must be remembered in order that the pupil may properly organize and orient what he learns. Memorization in the social sciences as in other fields requires repetition, but, as has been emphasized in other connections, mere repetition is not sufficient. Although it is not possible to formulate in detail the procedure to be followed in memorizing dates, names, etc., the results of experimentation on this topic justify the rule that the pupil should first understand what he wishes to remember.[1] Attempts to memorize facts that have little or no meaning for the pupil will not be efficient. Facts will be more easily remembered if they are organized and systematized. Some authorities recommend that a few pivotal dates be definitely memorized and that the time of other dates be related to these dates. Occasionally a mnemonic device[2] is helpful.

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[1] A number of such activities are described by PARKER, S. C.—*Types of Elementary Teaching and Learning.* Boston: Ginn and Company, 1923, Chapter IX.

**Acquiring ideals and other general patterns of conduct.**—History affords many opportunities for creating situations in which certain ideals are likely to be acquired. Reading accounts of historical events and descriptions of important persons tends to stimulate affective responses. Charters[3] recognizes personification as one method of teaching ideals. In this connection he points out that "the historical tale lends added impressiveness to the ideal because the child feels that the story is authentic."[4] The general pattern of conduct described by the ideal ceases to be abstract, and the pupil realizes that "men have actually stood for the principles described." Charters also calls attention to the fact that "words fitly chosen touch our hearts," and cites as an illustration Joaquin Miller's poem "Columbus."

**Measuring achievement in the social sciences.**—Information may be measured by appropriate tests. The principal problem in this connection is to devise an instrument that will be sufficiently extensive but will not require excessive time for its administration. To meet these requirements, ingenious types of "new examinations" have been devised.[1] When used for measuring information these tests are reasonably satisfactory, but it should be remembered that achievement in the social studies is not limited to information. Hence complete measurement of the achievement requires the use of other instruments. In the general discussion of the measurement of achievement[2] the difficulty of measuring such general patterns of conduct as "historical sense" and ideals was pointed out.

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[1] See page 166.

[2] See pages 166–67.

[3] Charters, W. W.—*The Teaching of Ideals.* New York: The Macmillan Company, 1927, Chapter XIII.

[4] *Ibid.*, p. 285.

## LEARNING EXERCISES FOR THE READER

1. How does algebra differ from arithmetic?
2. Should algebra be a required subject in high school?
3. Compare some textbook in algebra published a few decades ago with some recent textbook in this subject. What are the most striking differences? How can they be accounted for?
4. Explain Thorndike's statement, "It so often happens that the really effective principle is the product of the habits, not their producer." (See page 513.) What are the implications of this statement for the teaching of algebra?
5. What is meant by saying that "our present definitions of algebraic abilities are not satisfactory"? What bearing does this fact have on the construction of achievement tests in algebra? (Recall the meaning and the significance of the validity of a test.)
6. What do you regard as the chief defect in the manner in which most pupils study geometry? What suggestions can you offer for correcting this weakness?

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[1] For descriptions of "new examinations" in the field of the social sciences see Dawson, Edgar.—*Teaching of Social Studies.* New York: The Macmillan Company, 1927, pp. 345–52.

[2] See pages 309–10.

7. What dangers are involved in attempting to introduce demonstrational geometry at the beginning of the study of this subject? What substitutes for it can you suggest?

8. Of what importance is memory in the study of geometry?

9. Read Inglis—*Principles of Secondary Education*, pages 425–438, and ascertain his answers to the following three questions:

   a. What purposes does language serve?
   b. In what ways is one's language developed?
   c. What are the chief obstacles to the development of one's native tongue?

10. How does the use of slang affect the range and precision of one's vocabulary?

11. List all the characteristics of a theme that you think should be taken into consideration in evaluating it. (See pp. 525–27, 529–30, 536–37.) On a basis of one hundred points as the maximum possible total score, assign to each characteristic the number of points you think it deserves. (Such a scale is necessarily an arbitrary one.)

12. How does your reading vocabulary compare with your writing vocabulary? With your speaking vocabulary? What psychological explanation can you give for your answers?

13. What is superstition? Should the study of natural science affect a person's superstitious beliefs and practices? Illustrate.

14. What part should imagination play in the study of natural science?

15. What degree of emphasis should be placed on the mathematical aspects of high-school physics and chemistry?

16. Physics and chemistry are commonly regarded as being among the more difficult subjects studied in high school. Wherein does their difficulty lie?

17. In what sense may the various social studies be properly called "sciences"?

18. Which of the three types of controls of conduct should occupy the most prominent place among the objectives of social science?

19. Give three illustrations of problem-solving in history.

Ideal
ecreation
1. Change
2. Relax - no strain - no tension (?)
3. Enjoyment

Prerequisites of mental rec

Tuesday

# CHAPTER XIV

## MENTAL HYGIENE

**The problem of this chapter.**—Mental efficiency, like physical efficiency, may be increased by observing certain principles and by engaging in activities designed to promote mental fitness. It is the problem of this chapter to point out certain principles relating to mental efficiency and to indicate some means of attaining it.

In attempting to deal with this problem, the present writers are aware that our knowledge relating to mental health is meager; but the practical importance of mental hygiene is so apparent that it seems justifiable to include some treatment of the topic. Moreover, it is doubtful if many teachers attain their maximum efficiency in mental activities, and a consideration of conditions essential for mental health and the means proposed for promoting mental efficiency may afford a basis for self-improvement. Furthermore, study of the topic should enable them to deal more intelligently with students who appear to be handicapped by conditions capable of modification by suitable treatment. The reader, however, should approach the study of the following pages with the realization that there are many gaps in our knowledge in the field of mental hygiene and hence that many of the statements must be considered tentative.

**Abnormal mental conditions.**—It may be helpful, as an approach to the discussion of the hygiene of the normal mind, to consider briefly some abnormal mental conditions that result in maladjustment of the individual to his environment. These conditions may be either intellectual deficiencies or emotional abnormalities.

We have seen, in Chapter X, that intellect in man is distributed in accordance with the normal curve. Most persons have an average amount of intelligence, and relatively few have a great excess above, or a great deficiency below, the average amount. Although the relative number of those who are so deficient as to be recognized as feeble-minded is small, the total number of such cases in our nation is probably larger than the uninformed reader would suppose.

It is difficult to say just how far below normal one's mental condition must be before one can be classified as definitely feeble-minded. There is, of course, no sharp line of demarcation between normal persons and the feeble-minded.[1] It should be recognized, also, that intelligence is not the only factor to be taken into consideration in determining one's mental status. Emotional balance and control must also be considered. A marked abnormality with respect to one of these factors may be accompanied, and in some measure compensated for, by a lesser degree of abnormality with respect to the other factor. Any definition of feeble-mindedness in terms of I. Q., therefore, is arbitrary and uncertain. Terman,[2] however, suggests the following interpretation of intelligence quotients:

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[1] The reader will remember, from the discussion in Chapter X, that the curve of distribution of human traits is continuous.

[2] Terman, L. M.—*The Measurement of Intelligence.* Boston: Houghton Mifflin Company, 1916, p. 79.

| I.Q. | Classification |
|---|---|
| Above 140 | "Near" genius or genius |
| 120–140 | Very superior intelligence |
| 110–120 | Superior intelligence |
| 90–110 | Normal, or average, intelligence |
| 80–90 | Dullness, rarely classifiable as feeble-mindedness |
| 70–80 | Border-line deficiency, sometimes classifiable as dullness, often as feeble-mindedness |
| Below 70 | Definite feeble-mindedness |

Terman states that, of the I.Q.'s obtained from 1,000 unselected children, one per cent were 70 or lower. If this ratio is assumed to be fairly representative of our nation as a whole, there would thus be approximately 120,000 feeble-minded persons in our population. Pressey[1] estimates, on the basis of the results yielded by the draft, that there are more than 700,000 feeble-minded persons in our country outside of institutions.

It should be noted that the feeble-minded do not constitute the only cases of marked mental inadequacy. This term is applied only to those whose deficiency is due to incomplete mental development. Another group, known as dements, consists of those who, through injury or disease, have lost some part of the mentality which they formerly possessed. They may at one time have possessed normal, or even superior, mentality, whereas the feeble-minded have never been normal. The number of the dements—commonly called the insane—is also very large. Thus, Pressey[1] states that, according to the results of an investigation of mental defectives in Indiana in 1918, about 2.2 per cent of the general population within a certain area were insane, feeble-minded, or epileptic. Pollock and Malzberg, of the New York State Department of Mental Hygiene, conclude, on the basis of a study of defectives in that state, as follows: "It appears that approximately 4.5 per cent of the persons born in the state of New York may, under existing conditions, be expected to succumb to mental disease of one form or another, and become patients in hospitals for mental disease. In other words, on the average, approximately one person out of 22 becomes a patient in a hospital for mental disease during the lifetime of a generation."[2] This ratio is made impressive by the writers when they point out that, of the 1,030,000 boys and 990,000 girls in the public schools of the state of New York, 51,500 and 44,000 respectively may be expected to develop serious mental disease and become patients in institutions for the mentally disordered.

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[1] Pressey. S. L. and Pressey, L. C.—*Mental Abnormality and Deficiency.* New York: The Macmillan Company, 1926, p. 261.

Such appalling waste of human life and happiness as is suggested by the preceding statements is ample cause for grave concern. Some remedy for the situation would seem to be imperative. A practicable remedy for all cases of abnormality, however, is not easily prescribed. It appears that a majority of cases of feeble-mindedness are of hereditary origin and that heredity is very commonly at least a predisposing factor in all cases of abnormality.[3] Feeble-mindedness is incurable and only a small per cent of dements are ever restored to their original status. It follows, therefore, that, so far as markedly abnormal cases are concerned, any efforts in the direction of mental hygiene must be largely preventive in character.

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[1] Pressey, *op. cit.*, p. 260.

[2] Pollock, H. M., and Malzberg, Benjamin.—"Expectation of Mental Disease," *Mental Hygiene*, 13:132–63, January, 1929.

[3] Pressey (*op. cit.*, p. 272) mentions four important predisposing causes of abnormal mental states, namely: (1) heredity, (2) syphilis, (3) alcoholism, and

**Borderland conditions.**—Large as is the number of abnormal cases, there are even more persons who, though not definitely classifiable as feeble-minded or insane, depart sufficiently from normality to be regarded as decidedly unhealthy mentally. Their deficiencies may be either intellectual or emotional in character, or both. No attempt will be made here to describe the more common types of disorders.[1] Among those who may be regarded as borderland cases are the emotionally unstable, who at times exhibit anomalies of character and at other times are normal; the hysterical; those who are subject to morbid fears and obsessions; the emotionally exhausted, who are morbidly depressed, or melancholic; and the cranks and fanatics.

**Normal individuals.**—A normal condition of mental efficiency and health should not be interpreted as a perfect or ideal condition, but only as the condition that characterizes the normal or typical person. Just as the individual in normal physical health and vigor may be subject to minor ailments and bodily defects, so the normal mental condition may be characterized by traces of unwholesome and undesirable elements. Perfection is probably as rare in the one case as in the other. Hence,

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(4) morbid emotional development. He also mentions two types of exciting causes—physical weakness or exhaustion, and emotional shock or strain.

[1] The reader who is interested in this topic may consult PRESSEY, *op. cit.*, Chapter VII, for a general discussion and descriptions of individual cases. See also WALLIN, J. E. W.—*Clinical and Abnormal Psychology*. Boston: Houghton Mifflin Company, 1927. 649 pp.

in speaking of school children, Wile says: "Schools must recognize that all children present some qualitative or quantitative deviations from the theoretic norms of child structure and function. Mental hygiene concerns every child."[1]

That some measure of mental unhealth may, at least at times, be ascribed to everyone, is apparent from a consideration of some of the causes of abnormal or pathological conditions. For example, emotional unbalance and mental inadequacy sometimes follow experiences involving emotional shock and strain, as in the case of deep grief, fear, or anger. Again, we hear much nowadays of such matters as repressions, emotional conflicts, suppressed desires, and complexes as gateways to mental disorders. A person may have some strong desire[2] to which he cannot give expression because of shame, fear, sense of duty, or some other restraining influence. He may even suppress it, or exclude it from his conscious life, but he is not thereby freed from it. It still ". . . acts in a way like a concealed infection which occasionally breaks out—sometimes in ways quite mysterious to the patient—but for the most part operates subtly and insidiously to poison the whole mental and emotional life without making its presence known in any obvious or specific way."[3]

Such emotional experiences as those just mentioned are, in some measure, common to all persons at some time in life. If the hereditary neural foundations are inadequate to withstand them, or if they are too numerous or too acute, or if they are not counteracted by proper attention and treatment, they may result in abnormal conditions. Even under the most favorable circumstances they must tend to operate toward some degree of mental unhealth. They must inevitably interfere, more or less, with the individual's happy, effective adjustment to his environment.

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[1] Wile, L. S.—"Mental Hygiene in the Public Schools," *Mental Hygiene*, 13:70–80, January, 1929.

This writer defines mental hygiene as follows: "Mental hygiene is merely the science and the art of preserving mental health, and of preventing mental inadequacy from any and every cause, so far as may be possible."

[2] The Freudians emphasize sex matters as the source of such conflicts. It is true that they are frequently the source, but they are not the sole one. Hatred, envy, jealousy, shame, and many other emotional states may result in conflicts.

[3] Pressey, *op. cit.*, p. 55.

[illegible]
10:00–10:30 [illegible]
10:30–11:30 [illegible]
[illegible]

**The school as an influence toward mental health.**—The discussion thus far may be summed up in a few statements that are of great significance to the teacher. In the first place, some children are hopelessly feeble-minded and can never be brought to a level of normal mentality. Secondly, many more, though not feeble-minded, will, under present conditions, succumb to mental diseases and become definitely abnormal. Some of these may recover if proper treatment is given, and many, perhaps, could be saved by proper preventive measures. Finally, since perfect mental health is not characteristic of even the normal person, mental hygiene has a service to render in the case of every child.

It is not the purpose of this chapter to consider the treatment of abnormal cases. These rarely are, and never should be, in the public school, and are therefore not of primary concern to the teacher. It would be appropriate to discuss at length the problem of maintaining a wholesome emotional balance in the normal child, but our knowledge of the proper procedures is too limited to make possible an adequate treatment of the problem. We shall therefore have to be content with a few brief suggestions bearing upon the emotional guidance of the child, after which we shall turn to other aspects of the maintenance of mental efficiency.

**Influence of pre-school and out-of-school life.**—The school is not, of course, wholly responsible for the mental health of the child. Some condition of mental health —often an undesirable one—exists in the child when he enters school. There seems to be an increasing tendency on the part of psychologists and students of child nature and development to regard the early years of the child's life as the crucial period for determining his character. The attitudes and tendencies toward conduct that are built up during this period are fundamental and tend to endure. Thus, the child may come to school already "spoiled," conceited, painfully self-conscious, timid, fearful, subject to "temper tantrums," negativistic (disposed to respond oppositely to any request or suggestion), or possessed of other unwholesome mental traits. Furthermore, out-of-school influences continue to operate on the child throughout his school career with beneficial or harmful effects. The school should do what it can toward the correction of defects for which it is not responsible, but especially should it seek to avoid accentuating those that are present, or introducing others.

**The desirability of happiness in school life.**—School life should be a happy life. "Happiness," says La Rue,[1] "is, in general, the sign of mental health." If unhappiness can be taken, generally speaking, as an evidence of unwholesome mental conditions, one may question the total value of school training in the case of the child who thoroughly dislikes school, his teacher, his lessons, and all the activities in which he engages there. Fortunately, cases of extreme discontent with school life are relatively infrequent, and undoubtedly school life is more attractive now than formerly. The poet of an earlier generation speaks of

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[1] La Rue, D. W.—*Mental Hygiene.* New York: The Macmillan Company, 1927, p. 11.

> The feet that *creeping* came to school
> Went *storming out* to playing.

No doubt children will continue to enjoy the "playing" more than the work of the schoolroom, and the happiness attending play adds much to the enjoyment of the total school life. If, however, the general attitude, day by day, of the children in any schoolroom is one of discontent and helpless submission to an uninteresting and unwelcome state of affairs, the teacher may well consider the desirability of so modifying the school life that some measure of joy and content may prevail.

**The avoidance of worry.**—One cause of unhappiness in school is worry. Though by no means all children are subject to worry, it, in some cases, assumes very detrimental proportions. In his list of "principles of mental hygiene" Burnham[1] gives first place to "attention to the present situation." Worry about the past or concern about the future is detrimental to a person's mental processes. Illustrations of this principle are afforded by pupils who are unable to forget their failures or humiliations, or who worry over an approaching examination. Although it is customary for teachers to complain of the carelessness of children, it is probably "one of the marks of sanity."[2]

The principle of "attention to the present situation," however, must be applied intelligently. Burnham appropriately points out[1] the apparent conflict between it and the belief that "children should be taught to work for distant ends, to be cautious, to be deliberate, to restrain the impulses of the moment, to have provision of the future." The teacher's problem is to secure a proper balance between attention to the present and concern for the future. Both the happy-go-lucky attitude and worry should be avoided. Individual differences are important in this connection; a reprimand that stimulates in one pupil a wholesome concern about his work may cause another to worry and consequently become less efficient mentally.

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[1] Burnham, W. H.—*The Normal Mind.* New York: D. Appleton and Company, 1924, p. 642.

[2] *Ibid.*, p. 647.

**Prevention of "inferiority complexes."**—We have spoken in an earlier chapter[2] of the importance of a feeling of confidence as a response to any situation calling for action on the part of the individual. The potency of an inspiration is readily recognized. But an inspiration appears to consist essentially of two factors—a desire to achieve something and a belief that the achievement is possible. In contrast with the confident or the inspired person is the individual who is convinced of his own incompetence or unworthiness. He regards himself as inferior to others and concedes defeat without a struggle. He therefore shrinks from situations which should offer him a challenge, and which often present opportunities for worthy achievement. He is likely to be discontented or even despondent because of his feelings of inferiority, and for him the battle of life has no zest. Such is the deplorable lot of the person who is handicapped with an "inferiority complex."

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[1] Burnham, *op. cit.*, p. 646.

[2] Chapter III, pages 106–07.

An inferiority complex may result from the consciousness of some relatively inconsequential defect or some minor defeat or humiliation. Certainly a succession of such experiences will, in the case of many children, produce unwholesome results. Hence there is grave danger in procedures which, intentionally or otherwise, lead repeatedly to humiliation and a sense of failure. The pupil must be led to maintain his self-respect and faith in himself, and to this end the teacher should manifest respect for the pupil. So far as may be possible, the pupil's school life should be a series of successes rather than, as is too often the case, a succession of partial or complete failures.

**The "gospel of the task."**—A basic principle in the treatment of pathological cases is "to give opportunity for significant tasks."[1] "For normal men and women, also, the gospel of the task is quite as important for the maintenance of health as in the education of children and defectives."[2] The "gospel of the task," which Burnham emphasizes, is merely that complexes, inhibitions, and the like are unfortunate "conditioned reflexes" or associations, and that their cure is to be effected by responding to appropriate tasks (stimuli). In many cases interesting work has a wholesome effect. Psychiatrists frequently effect cures by getting the patient to talk freely and without reservation about his trouble. Burnham[3] tells of a man who complained that "he had lost interest in his work" and that "little things worried him." The physician whom he consulted asked: "What is one of the little things that worry you? Give me a definite concrete example."

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[1] BURNHAM, *op. cit.*, p. 615.

[2] *Ibid.*, p. 617.

[3] *Ibid.*, p. 625.

The man testified that this question "was worth the fee paid," because it suggested to him what he needed. It functioned as a "significant task" and Burnham points out that if the physician had asked "a score of such questions, and had prescribed the task of writing out the answers, he would have placed the man on the road to recovery."

The application of the "gospel of the task" in dealing with school children is obvious. The pupil who dislikes school work is merely making an undesirable response to the school situation. Likewise inferiority complexes, worry over examinations, and the like, represent learned responses, and the cure is to be effected by securing desirable responses to appropriate stimuli. This general procedure is simple, but the application to particular cases is difficult and requires a high degree of resourcefulness and skill on the part of the teacher.

**The need of the specialist in schools.**—Many cases of mental unhealth in school children require the attention of one with more knowledge and training in the field of mental disease than can be possessed by the teacher. The psychologist and psychiatrist should be regarded as no less a necessary part of the school staff than the physician and nurse. The teacher should not be expected to deal with the more troublesome cases of mental unhealth. At least he should have access to specialists for securing advice in regard to particular cases.

**Physical fitness a prerequisite for mental efficiency.**—Although physical fitness is not necessarily accompanied by a high level of mental efficiency, a person who is not physically fit is usually handicapped in his responses to stimuli—especially those involved in learning. Adenoids, diseased tonsils, infected teeth, indigestion, constipation, and other physical disorders are generally recognized as relatively serious handicaps to learning and other forms of responses. Consequently one who desires to attain a high level of mental efficiency should also endeavor to become physically fit.

La Rue[1] emphasizes the fact that "a person is a biomental unit." "Every organ projects its influence into the mental field."[2] Consequently a teacher's efforts to improve the mental fitness of his pupils should begin with attention to their physical fitness. Where a school nurse is employed, or provision is made for medical inspection, the teacher's responsibility is lessened; but he should constantly bear in mind the principle that physical fitness is a prerequisite for mental efficiency, and that the alert teacher will find many opportunities for making suggestions or giving advice.

**Good vision and hearing necessary for efficient learning in school.**—It is obvious that a child in our schools is seriously handicapped as a learner if his vision or hearing is defective. It is true, of course, that children who are blind or deaf can and do learn, but, obviously, they cannot be efficient learners under typical school conditions.

The correction of defective vision and hearing should be left to the specialist, but the teacher can render service, especially by maintaining the best possible lighting in the schoolroom and by arranging the seating so as to favor pupils who are defective in these respects. Frequently the teacher may note symptoms of defective vision and suggest to the parents that the child be examined by a competent oculist. Unfortunately the person with defective vision often is not aware of his condition, because he usually assumes, just as most people are apt to assume, that he sees just as others do. A psychologist who secured his doctorate working on visual perception found in his researches that he himself had suffered from a visual defect for years. The intelligent high-school or college student who does not enjoy reading is to be suspected of having defective vision. A visual defect that is not corrected during childhood may cause a permanent distaste for reading.[1]

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[1] La Rue, D. W.—*Mental Hygiene*. New York: The Macmillan Company, 1927, pp. 76f.

[2] *Ibid.*, p. 85.

Many teachers have reported dramatic and highly satisfying results that followed when pupils were fitted with appropriate glasses. Faces which had borne the expressions characteristic of defeat repeatedly experienced have become alight with the consciousness of success achieved. The sight of such a face becoming radiant with new interest furnishes the basis for the enthusiastic report of a teacher who had persuaded a pupil's parents to provide for examination of the eyes and correction of vision. One student in college reported her first view of the stars in the night sky after donning spectacles. Such experiences bring large returns in satisfaction to the teacher.

Unless the pupils have been carefully tested for visual defects and appropriate corrections have been made, the teacher may be quite sure that one or more pupils in a class of twenty are suffering from a visual deficiency which is a serious handicap. There is ample and convincing evidence to support the statement just made. Starch[1] makes the general statement that from 25 to 33⅓ per cent of the school children have visual defects sufficiently serious to demand some attention. Terman[2] says: "The above statistics, chosen from innumerable investigations in diverse parts of the world, amply demonstrate that from 10 to 30 per cent of the school population have vision sufficiently imperfect to demand correction by glasses." In a recent report[3] of a joint committee of the National Education Association and the American Medical Association the proportion of eye defects among school children is estimated at 12½ per cent. In this report children in rural districts appear to have more defects than those in city districts. For example, a report from Pennsylvania shows 16.8 per cent of 500,000 children in rural districts and 8.5 per cent of 370,000 children in urban districts having defective vision. For Iowa the corresponding per cents are 14.4 and 6.3.

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[1] Swift, E. J.—*Youth and the Race.* New York: Charles Scribner's Sons, 1912, pp. 94–95. Gives an interesting illustration of a pronounced dislike for reading due to a visual defect.

The information in regard to auditory defects is less definite; but it is clear that a significant proportion of school children have defective hearing. Results from a number of investigations are summarized in Table XII. It is apparent that defective hearing was defined differently in several of the inquiries. The high per cents mean that minor defects have been included, but in the case of New York City it is probable that a child must have been nearly deaf before the case was counted as a defect. Terman concludes "that from 10 to 20 per cent of school children do not hear normally and that the hearing of from 2 to 5 per cent is very seriously impaired."[1]

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[1] STARCH, DANIEL.—*Educational Psychology.* New York: The Macmillan Company, 1927, pp. 126–39.

[2] TERMAN, L. M.—*The Hygiene of the School Child.* Boston: Houghton Mifflin Company, 1914, p. 252.

[3] Quoted in *School and Society*, 22:298, September 5, 1925.

TABLE XII. FREQUENCY OF AUDITORY DEFECTS.[2]

| INVESTIGATOR | PLACE | NUMBER OF CHILDREN | PER CENT REPORTED DEFECTIVE |
|---|---|---|---|
| Cheattle | London | 1,000 | 50 |
| Weil | Stuttgart | 5,905 | 31.22 |
| Felix | France | 1,038 | 31 |
| Bezold | Munich | 1,918 | 25.8 |
| Gelle | Paris | 1,400 | 20 to 25 |
| Smedley | Chicago | 5,760 | 23 |
| Medical Examiners | Five East-End Schools at London | 1,006 | 7.2 |
| Bryan | Camden, N. J. | 8,110 normal age<br>2,020 retards | 4<br>6 |
| Medical Examiners | New York City | 266,426 | 0.5 |

Norsworthy and Whitley place the occurrence of defective hearing at 20 per cent.[3] Starch[4] "thinks from 5 to 10 per cent of the pupils suffer from defective hearing of a sufficiently serious character to interfere with their school work and to require medical attention.

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[1] TERMAN, *op. cit.*, p. 223.

[2] Abstracted from TERMAN, L. M.—*The Hygiene of the School Child.* Boston: Houghton Mifflin Company, 1914, p. 222.

[3] NORSWORTHY, NAOMI, and WHITLEY, M. T.—*Psychology of Childhood.* New York: The Macmillan Company, 1918, p. 122.

[4] STARCH, DANIEL.—*Educational Psychology*, New York: The Macmillan Company, 1927, p. 127.

**Effect of environmental factors upon mental efficiency.**—Although it is generally believed that "bad air"—i.e., air low in oxygen content and high in carbon dioxide content—decreases mental efficiency, scientific investigation has revealed that high temperature or humidity, or both, are more detrimental factors. Furthermore, it has been shown that even high temperature and humidity exert a relatively slight direct effect upon mental efficiency. Thorndike, McCall, and Chapman[1] made an elaborate series of tests of the mental efficiency of persons working under a variety of carefully controlled conditions. In the summary it is stated that under the conditions of the experimentation, "when an individual is urged to do his best he does as much, and does it as well, and improves as rapidly in a hot, humid, stale, and stagnant air condition as in an optimum condition."[2]

Caution should be exercised in applying this conclusion to school children, but it appears justifiable to say that the purity of the air, the temperature, and the humidity probably are not potent factors in determining mental efficiency. This statement should not be interpreted to mean that teachers should neglect the temperature and ventilation of their classrooms. These matters should receive attention, but the teacher should endeavor to keep his pupils from developing fresh-air or temperature complexes.

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[1] THORNDIKE, E. L., McCALL, W. A., and CHAPMAN, J. C.—"Ventilation in Relation to Mental Work," *Teachers College, Columbia University Contributions to Education*, No. 78. New York: Bureau of Publications, Teachers College, Columbia University, 1916. 83 pp.

[2] *Ibid.*, p. 75. Perhaps this investigation should be interpreted as indicating that one *can* learn as well under the conditions described as under the more favorable conditions. Everyday experience with pupils shows, however, that unfavorable conditions with respect to temperature, ventilation, and humidity usually operate to produce restlessness and inattention.

It is likely that similar conclusions are justified relative to other environmental factors. Noises are usually irritating, and interfere with study; but many persons learn to work in crowded offices and other places where there are many distracting noises. Persons who travel learn to work on trains. Hence it appears that although a quiet place is desirable, the presence of noise does not make a high degree of mental efficiency impossible. If circumstances make it impossible for the child to have a quiet place for study, he should not accept this condition as an insurmountable obstacle. It is possible for him to learn to be mentally efficient in spite of the undesirable conditions.

**Relation of drugs to mental efficiency.**—The question most frequently raised in this connection is in regard to the effect of smoking upon mental efficiency. There is a widespread conviction that smoking is "detrimental to scholarship in the high school." On the basis of a study of school records O'Shea concluded that on the high-school level, "tobacco exerts a depressing influence upon school work, the depressing influence increasing according as the amount of tobacco consumed increases."[1] A similar conclusion was reached relative to students of college level.[2] Laboratory studies indicate that "this detrimental influence is due, at least in part, to the direct depressant drug effect of tobacco."[3]

Occasionally teachers encounter cases involving the use of other drugs. Sometimes they are taken surreptitiously by pupils, but more frequently they are taken in the form of medicine in homes where "dosing" is customary. Although cases of mental inefficiency due to drugs are relatively rare, the teacher should not overlook this possibility when dealing with a case difficult to diagnose.

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[1] O'Shea, M. V.—*Tobacco and Mental Efficiency.* New York: The Macmillan Company, 1923, p. 157.

[2] *Ibid.*, p. 234.

[3] In another place O'Shea points out that the effect of tobacco is not uniform, and that "it is impossible to say what the effect of smoking a pipe of tobacco would be upon the mental processes of any individual at any given time." *Ibid.*, p. 220.

**Mental fatigue.**—A condition commonly designated as "fatigue" is generally believed to be created by intense and prolonged mental activity. When a person works continuously for several hours at a desk he "feels fatigued." This feeling, strange as it may seem, is due partially to his physical activity. He has been maintaining a relatively fixed posture, and if he is not accustomed to sitting at a desk, he has been exercising muscles that have been little used. If he has been reading, there has been prolonged activity of the muscles of the eyes. His vocal organs probably have been active even though he may not have spoken any words. Hence, what is commonly called a "feeling of fatigue" is not the resultant of mental activity alone. In fact, the mental activity probably makes a relatively minor contribution.

The nature of mental fatigue is not understood. It is unsatisfactory to define it in terms of the decrease in ability to do specified mental tasks, because loss of interest or boredom and physical fatigue also contribute to this condition. There is experimental evidence that when subjected to continued activity parts of the nervous system become less efficient. This is illustrated by the quickness with which a person becomes insensitive to tastes and odors. The explanation of these phenomena is that the olfactory and taste cells become fatigued and fail to function effectively. A similar condition appears to be created in other parts of the nervous system, especially the synaptic connections. A condition in the nervous system, however, can be measured only through its effect upon a person's performance or bodily function.[1]

One of the most dependable studies of fatigue has been reported by Arai who concluded that "difficult and disagreeable continued work brings about a decrease of the function exercised" and it "may have an unfavorable influence on other functions."[2] In this experiment the "difficult and disagreeable work" consisted of multiplying mentally pairs of four-place numbers such as 7,954 by 3,528. In order to make the work sufficiently difficult in the latter part of the study, the subject performed the multiplications with closed eyes. In the first part, the work was continued from 1:45 p. m. to 10:07 p. m. with slightly more than an hour taken out for dinner. Later the work was continued from 11 a. m. to 11 p. m. on each of four successive days. The subject was the investigator, a mature woman. The time taken to do an example was increased less than one hundred per cent—a surprising fact when we consider the nature of the work and the length of time the work was continued.

Such studies suggest that students in the high school or college seldom, if ever, become fatigued mentally to a degree that materially affects their efficiency. Consequently it appears that there is little cause for concern about mental fatigue. This does not mean, however, that no ill effects are to be expected from prolonged mental activity such as may be stimulated by long and difficult assignments or by long examinations. On page 573 it was pointed out that "feelings of fatigue" are probably due mainly to physical activity, and that prolonged study by children is likely to produce harmful muscular fatigue, especially of the eye, and of the hand when writing is involved. Furthermore, prolonged work at uninteresting as well as disagreeable tasks is likely to engender undesirable attitudes. Consequently, relatively short periods and frequent changes in type of work are desirable, especially for young children.

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[1] For a good summary discussion of "fatigue" see SANDIFORD, PETER.—*Educational Psychology.* New York: Longmans, Green and Company, 1928, Chapter XIII.

[2] ARAI, TSURU.—"Mental Fatigue," *Teachers College Columbia University Contributions to Education*, No. 54. New York: Bureau of Publications, Teachers College, Columbia University, 1912, pp. 114–15.

**Loss of interest, and boredom.**—A decrease in mental efficiency may be due to loss of interest, or boredom, or both, and what is frequently called mental fatigue is really only a combination of these conditions. The influence of interest in one's work is generally recognized. Evidence of this recognition is afforded by the space devoted to the topic of motivation in texts on methods of teaching, and by the fact that prospective teachers are now being instructed in procedures and devices for stimulating interest. Book[1] uses the term "fatigue of the will" to explain a decline in mental efficiency. He points out that "one may actually get tired of trying," a condition likely to result when a person pursues a series of tasks of the same general type (such as may be presented by a school subject) over a period of several days or weeks. This decline in mental efficiency frequently results also from the routine of the home or office.

Many persons attempt to overcome loss of interest, boredom, and "will-fatigue" by indulging in certain activities, often to an excessive degree. They "let themselves go" and "blow off steam." It is, however, better to avoid these conditions. Book[1] gives the following suggestions:

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[1] Book, W. F.—*Learning How to Study and Work Effectively.* Boston: Ginn and Company, 1926, pp. 150f.

1. Do the hardest work first.
2. Get down to business at once when you start and thus profit by the impetus of a good start.
3. Cultivate the habit of succeeding with every task you undertake.
4. If you are a "slow starter," and hence require a 'warming up" period, keep up "full steam" until you have a positive accomplishment to show for your efforts.

**Effect of strenuous and prolonged physical exercise upon mental efficiency.**—When a person engages in vigorous activity involving the big muscles of the body, circulation of the blood is increased in order to supply extra nourishment and oxygen and to remove waste products. The heat generated by the action of the muscles results in increased activity of the sweat glands. Vital organs other than the heart and lungs are stimulated. If in addition the activity is play, there is mental relaxation. Hence big-muscle play activity in moderate amount contributes to mental efficiency. If, however, the physical exercise is strenuous and prolonged, the effect may not be beneficial. Football players and participants in other sports frequently insist that they are unable to study during the training season because they are mentally tired. It is likely that their testimony should be discounted to some extent, but physical activity does have a neural basis, and it is not unlikely that the physical exercise may have produced a condition that interferes with the efficient functioning of the nervous system. Consequently very strenuous and prolonged physical exercise should not be engaged in as a means of restoring a state of mental efficiency or as preparation for engaging in difficult mental activity.

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[1] Book, *op. cit.*, p. 153.

**Sleep, a means of recovering from fatigue.**—Sleep is nature's provision for recovering from fatigue. During normal sleep there is muscular relaxation and a minimum of activity in the nervous system. Fatigue products are eliminated or neutralized.

Habits of sleep vary. A person who usually sleeps soundly may occasionally have restless nights. Some persons are habitually sound sleepers; others sleep lightly and are easily awakened. Some persons appear to require from eight to ten hours or even more of sleep; others seem to find from five to seven hours sufficient. Some persons are able to go to sleep quickly upon retiring; others experience difficulty in going to sleep and a disturbance may result in the loss of most or even all of a night's rest. Some persons can go to sleep at any time and appear to profit as much or nearly as much from several short periods as from one continuous period; others appear to be able to profit very little from short periods of sleep. Some persons appear to find it necessary to maintain a definite and regular schedule in regard to sleep; others appear to suffer little or no inconvenience from irregular hours of retiring.

The significance of the preceding paragraph is that we cannot formulate a rule specifying the hour for retiring, the number of hours to be allowed for sleep, and the like. Adequate sleep is essential for a high level of mental efficiency, but sleep requirements appear to be subject to marked individual differences. Hence each person must determine his own requirements and then conform to them. Otherwise he cannot attain his highest level of mental efficiency. A few general rules are given here as suggestions, but the present writers are aware that they probably do not apply to all persons.

1. Have a regular hour for retiring.
2. Provide for eight hours of sleep unless you are certain you do not need that much. Children usually need more than adults.
3. Avoid eating and excitement just before retiring.
4. Go to bed with the intention of going to sleep. Do not carry your problems to bed with you. Dismiss all worries from your mind.[1]

**Mental recreation.**—Mental recreation does not necessarily mean freedom from mental activity. Many of the popular recreational activities among teachers, lawyers, and others who engage in rather intensive mental activities involve close attention and thoughtful planning. Chess and auction bridge are two illustrations. Even in some recreational activities that are primarily physical there is rather intense mental activity. This is true of billiards and golf.

If mental recreation involves mental activity, what are the conditions that must be met in order that an activity may be recreational? The first requirement is that there be resulting satisfaction. The conditions necessary for satisfaction are not clearly understood, but in general a person derives satisfaction from doing those things in which he is interested. Another requirement is that there should be a reduction of nervous tension. Competitive play, if taken seriously, does not bring mental relaxation. Finally, the activity should be of such a nature that there will be a change in the neurones involved. For example, a person who has been studying physics may secure mental relaxation by playing bridge or by reading a detective story.

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[1] La Rue insists that going to sleep is a habit and that "the average person can learn either to go to sleep at once, or to lie awake half of the night as he chooses." La Rue, *op. cit.*, p. 192.

**The value of mental relaxation.**—In his *Talks to Teachers on Psychology: and to Students on Some of Life's Ideals*, William James included a chapter bearing the title, "The gospel of relaxation." In this chapter he calls attention to the "intensity, rapidity, vivacity of appearance" which seem to represent "a nationally accepted ideal." These traits which James characterizes as "bottled lightning" are generally prized by the American people. Observers from other countries have remarked on the evidence of them in our facial expression. James calls "the American over-tension and jerkiness and breathlessness and intensity and agony of expression" "*bad habits*," and points out that mental relaxation is essential to mental efficiency. "It is your relaxed and easy worker, who is in no hurry, and quite thoughtless most of the while of consequences, who is your efficient worker; and tension and anxiety . . . are the surest drags upon steady progress and hindrances to our success."[1]

The teacher should recognize the value of relaxation as an aid to his own mental efficiency. He should also recognize the fact that his example in the classroom is a powerful determinant of the pupil's attitude. The teacher should secure a reasonable amount of mental relaxation and avoid exhibiting an attitude of "bottled lightning." He should also encourage his pupils to engage in mental activities that will bring mental relaxation. At times he may introduce such activities in the classroom.

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[1] JAMES, WILLIAM.—*Talks to Teachers on Psychology: and to Students on Some of Life's Ideals.* New York: Henry Holt and Company, 1899, pp. 215–16.

Participation in extra-curricular activities often results in mental relaxation.

**The effect of moods and attitudes.**—A person's mental efficiency is affected by moods, attitudes, dispositions, and the like, especially those that have become habitual. The pessimist is less efficient mentally than the optimist. A person with an inferiority complex is handicapped. A pupil who has developed a dislike for a particular school subject is not likely to succeed in studying it.

On the other hand, a desirable mood or attitude may contribute to a person's mental efficiency. In his list of "principles of hygiene," Burnham[1] includes "an active attitude in the face of difficulties," "confidence that results from action and an ordinary degree of success," and "scientific attitude." The last—which he describes as the "attitude of trying to find reality" or the "learning attitude"—is designated as "the most important condition of mental health, the most potent factor in integrating the personality." The common saying that "nothing succeeds like success" embodies a principle of mental hygiene. Success engenders "confidence," an attitude that is an asset in approaching a task involving difficulty.

**The influence of study habits.**—It has been generally assumed that conforming to certain procedures increases the effectiveness of a learner's efforts, and consequently that pupils should acquire certain study habits and avoid others considered undesirable. The arguments supporting this assumption are plausible. Certain study habits[2] appear to be valuable assets; others appear to be handicaps. For example, some pupils habitually budget their day so that they have time for their various tasks; others lead a "hand-to-mouth" existence and become chronic procrastinators. Some pupils approach the solving of a problem with a problem-solving attitude; others approach it with the attitude that the only essential requirement is to get the answer. Some habitually approach the reading of a book with the purpose of reading to remember; others adjust their purpose to the nature of the assignment.

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[1] Burnham, *op. cit.*, pp. 662f.

[2] One of the earliest and most widely read books on this topic is Whipple, G. M. —*How to Study Effectively*. Bloomington: Public School Publishing Company, 1927. 96 pp. Originally published in 1916. One of the most recent and most elaborate treatments is Book, W. F.—*Learning How to Study and Work Effectively*. Boston: Ginn and Company, 1926. 475 pp.

Certain inquiries[1] into the study habits actually used by pupils cast some doubt upon the validity of the assumption that conformity to the rules specified by writers on study procedures is essential to the attainment of a high degree of effectiveness as a learner. It appears that if students are classified into two groups, successful and unsuccessful, a considerable number of unsuccessful students will be found to have "good study habits," and a considerable number of successful students will be found to have "undesirable study habits." There are obvious explanations of this condition. In the report of one investigation it is pointed out that probably the value of a given study habit is dependent upon the degree of skill with which it is used.[2] Another possible explanation is that success in learning is more dependent upon other factors than upon study habits. In an extended study of the factors that contribute to success in college, Herriott[1] identified by means of partial correlation five major factors of scholastic success: (1) previous preparation, (2) intelligence, (3) study habits, (4) evaluative–non-evaluative attitude, and (5) persevering–vacillating attitude.[2] Judged by the size of the partial coefficients of correlation for the several factors, study habits are approximately as influential as intelligence but less influential than the other three factors, especially the two attitudes. As Herriott very properly points out, these conclusions must be considered tentative. His findings, however, are significant in that they call attention to the fact that the acquisition of good study habits does not insure a high degree of mental efficiency. In this connection it should be noted that pupils who are inefficient as learners may not need training in study habits as much as they need other types of remedial treatment.[3]

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[1] Webb, L. W.—"Students' Method of Studying a Certain Subject—Psychology," *Journal of Educational Psychology*, 11:193–206, April, 1920.

Deich, C., and Jones, E. F.—"A Study of Distinguished High-School Pupils in Iowa," *U. S. Bureau of Education Bulletin*, 1923, No. 46. Washington: Government Printing Office. 58 pp.

[2] Ross, C. C., and Kleise, N. M.—"Study Methods of College Students in Relation to Intelligence and Achievement," *Educational Administration and Supervision*, 13:551–62, November, 1927.

The publication of books setting forth principles and rules underlying methods of study indicates a growing belief that good study habits can be engendered by the use of a manual, and by class discussion of right methods of study. Butterweck[4] reports that both pupils of high

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[1] Herriott, M. E.—"Attitudes as Factors of College Success." *University of Illinois Bulletin*, Vol. XXVII, No. 2, Bureau of Educational Research Bulletin, No. 47. Urbana: University of Illinois, 1929. 72 pp.

[2] "Evaluative" and "non-evaluative" indicate two extremes of the same attitude. At one extreme is the student who exhibits a strong tendency to evaluate statements that he reads or that the instructor makes; at the other is the student who does not evaluate. A similar explanation applies to the "persevering–vacillating attitude."

[3] This point is elaborated by Woodring, M. N., and Flemming, C. W.—"Diagnosis as a Basis for the Direction of Study," *Teachers College Record*, 30:46–64, and 134–47, October and November, 1928.

[4] Butterweck, J. S.—"The Problem of Teaching High School Pupils How to Study," *Teachers College, Columbia University Contributions to Education*, No. 237. New York: Bureau of Publications, Teachers College, Columbia University, 1926, pp. 78–79.

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intelligence and pupils of low intelligence profit from these activities, but that the latter group "need a great deal of practice material used in its proper setting and consisting of the elements of a given study situation arranged in the order in which they are to be used in their ordinary study." This conclusion is in agreement with the general principle that the acquisition of a habitual procedure requires repetition.[1]

**Culture, a wealth of interests.**—A person's efficiency in responding to stimuli and situations is conditioned by what he knows. The expert in a given field is efficient within that field, but may be very inefficient in other fields. In order to be efficient in a broad sense, a person must possess a broad range of knowledge. Much the same idea is expressed by saying that his interests must be broad. In describing culture, Dewey has said: "There is perhaps no better definition of culture than that it is the capacity for expanding in range and accuracy one's perception of meanings."[2]

Friday

## LEARNING EXERCISES FOR THE READER

1. What constitutes a state of mental health?
2. Which of the following should be regarded as conditions of mental unhealth: pessimism, fear, ambition, self-confidence, conceit, hatred, despair, love, jealousy, remorse, grief, joviality, submissiveness?
3. Distinguish between insanity and feeble-mindedness.
4. What is meant by describing certain persons as "emotionally exhausted"?
5. Do you agree that "mental hygiene concerns every child"? Explain.

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[1] See pages 188f.

[2] DEWEY, JOHN.—*Democracy and Education.* New York: The Macmillan Company, 1916, p. 145.

Skinner Chap 22
Book - Learning
Burnham - Normal Mind

James - Talks to Tea
Whipple - How to Study

6. What is a "conflict"? a "complex"?

7. Can a distinction be made between mental health and mental efficiency?

8. Describe what should be regarded as proper physical conditions in a schoolroom.

Do 9. Prepare a list of the fifteen rules of study which you regard as the most helpful. (Consult Whipple's list, a summary of which may be found in Starch's *Educational Psychology*.)

10. There is evidence indicating that the number of pupils with visual defects increases throughout the school grades. Is it likely that teachers are in any measure responsible for the increase?

11. What meaning do you attach to the phrase "mental fatigue"?

12. Does it seem appropriate to speak of a "superiority complex"? If so, what meaning should be attached to the term? Should you regard the possession of a superiority complex as a condition of mental unhealth? As much so as the possession of an inferiority complex?

omit 13. The student will be repaid for reading: HART, BERNARD. —*The Psychology of Insanity*. Cambridge, England: University Press, 1925. 176 pp.

14. Describe the methods of the psychoanalyst. What is the theory underlying them?

15. List specifically the things a teacher can do in the interest of the mental health of his pupils.

Why do we need to study mental hyg
Distinguish betw Insanity + f.m.
"Conflict" - "Complex" - what are
~~Distinction~~ betw. mental health +
mental efficiency
Emot. exhaustion?
School do to promote mental health
Mental illnesses - worry, infer. complex
work, etc.

Reference - School of Review - Vol 33 - 174-8
Hide's - Teacher's philosophy
Book - Chap 12 - Study Habits

# CHAPTER XV

## HOW TO STUDY PUPILS

**The need for studying pupils.**—The existence of individual differences[1] implies the teacher's need to study his pupils as individuals. A class is not a homogeneous group of learners. The pupils assembled together for instructional purposes differ widely in interests, attitudes, intelligence, study habits, prerequisite training, and other characteristics that affect their responses to stimuli and consequently their learning. Even when homogeneous grouping is attempted by sectioning larger classes upon the basis of intelligence-test scores and other data, the members of a group will usually exhibit significant individual differences. Consequently a given question, explanation, reading assignment, or other stimulus frequently will elicit responses that are very different.[2] As a result, some of the members of the class will achieve the objectives set for them, but others will fail to do so even though all have been subjected to the same instruction. Efficient teaching requires that much of the instruction be individualized.[3] Efficient teaching also requires that much of the instruction be remedial, that is, be designed to correct errors and deficiencies. and to extend the learning accomplished. Therefore it is not sufficient merely to individualize instruction. The instruction itself must be adapted to the needs of the pupils; and, obviously, effective adaptation cannot be secured without adequate knowledge of the needs of individual pupils.

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[1] It will be helpful to review Chapter X in connection with the study of the following pages.

[2] This point was emphasized in the discussion of the psychology of certain school subjects. See especially pages 461–64, 486–87, 498–99.

[3] Several plans for individualizing instruction have been proposed. For a description of the Dalton Plan and other proposals see MONROE, WALTER S.—*Directing Learning in the High School.* Garden City, New York: Doubleday, Doran and Company, Inc., 1927, pp. 398f.

**Significant symptoms that should be noted in the observation of pupils.**—A teacher who is interested in his pupils as individuals endeavors to classify them as learners. Certain ones are labeled "bright," others are designated as "slow but persistent," and still others as being "bright enough but lazy." Estimates based upon observation are not highly accurate, but they will be more dependable if the teacher knows what symptoms are significant.

There are a number of significant physical symptoms that a teacher should not overlook. A strained facial expression when a pupil is reading is usually indicative of defective vision.[1] Mouth breathing, habitually poor posture, chronic headaches, sleepiness, and the like are usually indicative of a physical condition that handicaps the child as a learner. A pupil who goes to sleep in class may do so because he does not obtain sufficient sleep at home.

The child who is over age for his grade is likely to be below the average in intelligence and one who is younger than his classmates is likely to be brighter than the average. Pupils whose work from day to day is erratic are likely to differ from the typical pupil in significant respects. Irregular attendance is frequently significant.

The general quality of a pupil's work is significant, but excellent class work is not an infallible indication of superior ability. The pupil may be receiving help at home or may be making an unusual effort. Nor does unsatisfactory class work always mean that the pupil is lacking in intelligence.

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[1] See page 567.

In examining pupils' work teachers frequently attempt to ascertain only whether it is correct. Frequently the correctness of the answer to an arithmetical exercise is not as important as the method the pupil employed in arriving at the answer.[1] Likewise the pupil's method of answering a thought question in history may be more important than the answer he gives.[2] The objective to be attained is learning how to respond to thought questions rather than to learn the answers to certain questions. Consequently teachers should give attention to the pupil's methods of work. Such procedures as counting on the fingers in doing addition examples, repeating verbatim statements from the text in answering thought questions, using technical terms carelessly, and the like should be noted.

Many experienced teachers are very skillful in estimating the traits of their pupils, but as a rule it is advisable for a teacher to employ intelligence tests and other suitable instruments when he desires to know his pupils accurately.

**An elaborate study of individual pupils.**—Terman's report[3] of the *Mental and Physical Traits of a Thousand Gifted Children* illustrates the range of useful information about children that may be collected. In this investigation "about 65 pages of test and measurement data and about 35 pages of questionnaire data" were collected "for more than 90 per cent of the main experimental group of 643 subjects."[1] For collecting these data the following instruments were used:

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[1] See pages 482–83.

[2] See pages 183f.

[3] TERMAN, L. M., and others.—*Genetic Studies of Genius*, Vol. I. Stanford University: Stanford University Press, 1925. 648 pp.

1. Two intelligence tests (Stanford-Binet and National B)
2. The Stanford Achievement Test
3. A fifty-minute test of general information in science, literature, and the arts
4. A fifty-minute test of knowledge of and interest in plays, games, and amusements
5. A four-page interest blank
6. A two-month reading record
7. A sixteen-page home information blank
8. An eight-page school information blank
9. Whittier Scale for home grading
10. Character and personality tests
11. Interest test.

Obviously a teacher cannot make such an elaborate study of his pupils, but this list of instruments used by Terman and his co-workers suggests the range of information that may be collected when it is desired to study pupils as individuals. The reader should note that the list begins with two intelligence tests—one individual, and the other a group examination. The second item is an achievement test that includes the standard subjects of the elementary-school curriculum. Any competent teacher should be able to administer a group intelligence examination and an achievement test—such as the one used by Terman—and to interpret the scores secured. The list also suggests the desirability of employing tests of personality and character traits and of securing information in regard to the pupil's interests and his home.

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[1] TERMAN, *op. cit.*, p. 12.

Frequently information in regard to these factors leads to an explanation of unsatisfactory pupil status.

**Using group intelligence tests.**—A teacher who is interested in studying his pupils should administer a group intelligence test.[1] It is especially helpful to do this at the beginning of the school year when the teacher faces the task of becoming acquainted with a new group of pupils.

It is relatively easy to administer a group intelligence test. In the use of the simpler ones—for example, the Otis Self-Administering Test[2]—the procedure is such that a teacher should be able to administer it satisfactorily after a few minutes devoted to the study of the directions for giving it. In the case of the more elaborate group intelligence tests, a longer time will be required for a teacher to become sufficiently familiar with the directions, but no competent teacher should experience difficulty in attaining a satisfactory degree of skill in administering any of the group intelligence tests. He should endeavor to follow the directions verbatim, rather than merely to conform to their spirit, giving the instructions to the pupils in his own words. In administering a test the teacher should endeavor to secure normal responses from each of his pupils. If they make only half-hearted efforts to do the exercises, or if they are stimulated to make an unusual effort, the results will be lacking in validity, and hence will have only a limited usefulness.

In interpreting and using the scores obtained, the teacher should bear in mind the general limitations of group intelligence tests.[3] This admonition is especially important in the case of scores that indicate either a high or a low degree of intelligence. The score of a particular pupil *may* involve a relatively large error. We know that in a typical set of scores a few involve an error of several points, but usually we are unable to ascertain the magnitude of the error in the score of a particular pupil. A few scores involve errors so small that they may be considered negligible, but again we usually are unable to identify the pupils for which this is true. Hence it is necessary to exercise caution in interpreting and using the scores obtained by administering a group intelligence test.

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[1] See pages 269f. for a description of group intelligence tests.

[2] Published by the World Book Company, Yonkers, New York.

[3] See pages 281f.

**Using individual intelligence tests.**—Frequently it is helpful to supplement the use of a group intelligence test by administering an individual test, such as the Stanford Revision of the Binet Scale. A test of this type is not as easy to administer as a group test, and as a rule a teacher should not attempt to use an individual test until he has been adequately trained.

Terman states that satisfactory preparation can be secured in a three-semester-hour course, provided "it is properly supplemented by other courses in educational psychology."[1] In the case of the teacher in service, he advises careful study of "two or three books dealing with individual differences and the principles of mental testing"[2] as preliminary to the actual study of the Binet Scale and the directions for using it. After these are clearly understood, the teacher may begin testing children, and by the time fifteen or twenty tests have been made, "the mental age secured should be substantially the same as a trained psychologist would get."[3] Later, Terman[4] points out that it is much simpler "to acquire a reasonable degree of expertness in giving Binet tests" than to learn how to interpret and use the results, and he cautions the teacher not to interpret the test results too literally, or to depend upon them too exclusively. Terman's recommendations may seem somewhat severe, but certainly a teacher should not attempt to use an individual intelligence test without making careful preparation for the task. If possible, he should take a course in mental testing in which attention is given to the use of individual tests. When this cannot be done, he should exercise much caution in interpreting the scores secured until he is certain that he has become competent in administering an individual test.[1]

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[1] Terman, L. M.—*The Intelligence of School Children.* Boston: Houghton Mifflin Company, 1919, p. 292.

[2] *Ibid.*, p. 293.

[3] *Ibid.*, p. 294.

[4] *Ibid.*, p. 298.

**Using other psychological tests.**—Although it is important to secure a measure of a pupil's capacity to learn, the teacher should bear in mind that learning activity is influenced by attitudes, interests, study habits, and the like.[2] The tests now available for measuring such traits are less satisfactory than those used for measuring intelligence, but frequently they will yield valuable information. The Downey Will-Temperament Test is one of the most useful instruments in this field, but there are a number of other tests that a teacher may employ.[3]

Frequently in studying pupils who have become problem cases, it is helpful to use psychological tests other than those commonly called intelligence tests. A good illustration of the effective use of such tests is given by Bronner,[1] who employed form boards, construction tests, puzzle boxes, the Knox cube tests, the Stenquist test for mechanical ability, and the like. In general these instruments are for the trained psychologist, and their use should not be attempted by a teacher who has not had a special course of training.

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[1] A helpful reference on the training of teachers in mental testing is DICKSON, V. E.—*Mental Tests and the Classroom Teacher.* Yonkers: World Book Company, 1923, especially Chapters VI, VII, and XI.

[2] See pages 330f.

[3] See pages 330f. for description of several tests. For an illustration of the use of the Downey Will-Temperament Test see REAVIS, W. C.—"Utilizing the Results of the Downey Individual Will-Temperament Test in Pupil Administration," *School Review,* 33:174–83, March, 1925.

**Importance of identifying bright children.**—When attention is called to the need for studying pupils, we tend to think of those who are doing unsatisfactory work because they are lacking in capacity to learn. The teacher, however, should not overlook the fact that some bright pupils do not work up to the limits of their capacities, and that occasionally one fails to do even satisfactory work. Terman[2] cites the case of a twelve-year-old boy in the sixth grade whose teacher considered his work distinctly unsatisfactory. A mental examination showed that the boy was unusually bright, having an I.Q. of 140. Inquiry revealed that the boy had formed a dislike for his teacher because she had accused him of being untruthful. Woodrow[3] tells of a boy who exhibited decided mischievous tendencies. His teachers failed to understand him and consequently did not deal with him in the right way. After his ability was recognized and the instruction had been adapted to his capacity and interests, he stood at the head of his classes.[4] These cases are doubtless unusual, but it is certain that many pupils are more intelligent than they are estimated to be. A teacher is not likely to estimate a pupil's intelligence higher than it really is, but if he does so, the error is not a serious matter. On the other hand, failure to identify bright pupils represents inefficient teaching. Consequently, in studying pupils relative to their intelligence, emphasis should be placed upon discovering those pupils who are brighter than they appear to be.

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[1] Bronner, A. F.—*The Psychology of Special Abilities and Disabilities.* Boston: Little, Brown and Company, 1917. 269 pp.

[2] Terman, L. M.—*The Intelligence of School Children.* Boston: Houghton, Mifflin Company, 1919, p. 289.

[3] Woodrow, Herbert.—*Brightness and Dullness in Children.* Philadelphia: J. B. Lippincott Company, 1919, p. 292.

[4] Several somewhat similar cases are cited by Bronner. See especially *op. cit.*, pp. 222–24. See also in this connection Van Alstyne, Dorothy.—"A

**The need for a trained psychologist.**—In discussing the use of individual intelligence tests the need for special training was emphasized, but the teacher cannot be expected to become an expert in mental testing. Frequently in studying pupils who are recognized as problem cases, the services of a trained psychologist are needed. Most large school systems have recognized this need and maintain a department to which cases that the teacher is unable to diagnose may be referred.[1]

**Pupil questionnaires.**—Some teachers, especially in high school and college, ask their pupils to give them certain personal information, such as occupation of father, school previously attended, school subject liked best, vocational ambition, newspapers and periodicals read regularly, home conditions relative to study, extra-curricular interests, hobbies, and the like. Such information has been shown to be helpful in arriving at an understanding of many pupils who were failing to do satisfactory

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Study of Ten Gifted Children Whose School Progress Was Unsatisfactory," *Journal of Educational Research*, 8:122–35, September, 1923.

[1] The service that a trained psychologist can render is illustrated in the following article: FREEMAN, F. N.—"Types of High-School Students," *School Review*, 28:383–87, May, 1920. Freeman describes several typical boys referred to the psychological laboratory by the Principal of the University High School at the University of Chicago.

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work. Although the use of an elaborate pupil questionnaire may not be advisable as a regular procedure, the teacher should secure such information when he encounters a pupil who is difficult to understand.

**Making case studies.**—School psychologists, guidance directors, and special investigators have reported a large number of intensive studies of individual pupils.[1] Although it will seldom be feasible for the teacher to attempt elaborate case studies, these reports reveal the methods employed and suggest the procedures that the teacher may employ in dealing with problem cases. Case studies have revealed the fact that in many instances the cause of unsatisfactory school work is not low intelligence. In some cases the pupil has been found to possess average intelligence and occasionally to be bright. The beneficial effects of appropriate remedial instruction demonstrate that a careful study of individual pupils who are doing unsatisfactory work is likely to be very much worth while.

The data collected in making a case study are determined in part by the nature of the case, but usually include the following items:[2] (1) family history and status; (2) health history of pupil, frequently supplemented by physical, medical, and dental examinations; (3) school record, including attendance; (4) mental and educational examination by means of appropriate standardized tests; (5) reports from teachers in regard to the pupil's study habits, interests, social traits, etc.; (6) participation in extra-curricular activities and pastimes; and (7) miscellaneous data secured by means of a personal interview with the pupil. Obviously the teacher cannot be expected to be an expert in all of the fields represented, and, as indicated in the preceding pages, he will need to seek the assistance of the physician, dentist, clinical psychologist, and psychiatrist when an elaborate case study is being attempted. The teacher, however, may "interrogate the pupil with a view to inducing self-analysis," one of the methods of diagnosis recommended by Reavis.[1] The teacher may also secure valuable information by observing carefully the pupil's classroom work and by noting characteristic errors in his written work.

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[1] Several cases on the high-school level have been reported by Reavis, W. C.—*Pupil Adjustment in Junior and Senior High Schools.* Boston: D. C. Heath and Company, 1926, pp. 129–316. This volume includes a selected bibliography of case studies on pp. 317–21. A number of case studies have been reported briefly by Wentworth, M. M.—*Individual Differences in the Intelligence of School Children.* Cambridge: Harvard University Press, 1926. 162 pp.

[2] See Reavis, W. C., *op. cit.*, pp. 99–100, for outline of case records used in the University of Chicago High School.

A case study is not completed when the data have been collected. They must be interpreted; and this is by no means easy, especially when a number of causes contribute to the pupil's failure to do satisfactory work. Reavis[2] suggests the following classification of causes: (1) ineffective habits of work; (2) personality difficulties; (3) deficiencies in previous training; (4) physical defects; (5) mental disability; and (6) psycho-physical defects.

The procedure involved in making case studies is probably best understood by studying reports of the methods employed in representative cases. Reavis[3] describes the diagnosis of a high-school pupil who was socially maladjusted. Administration of the Terman Group Test of Mental Ability showed the pupil to be distinctly above normal in intelligence. A medical examination failed to reveal a cause for unsatisfactory work. The usual personal data and reports from his instructors during the first year failed to lead to a satisfactory diagnosis. A conference with his parents revealed that the pupil was an only child and that his home life had been unusual in certain significant respects. This information, together with reports from instructors during the second year, and data yielded by the Downey Individual Will-Temperament Test[1] furnished a basis for a satisfactory diagnosis. Reavis expresses the conviction that in the absence of a diagnosis "things would undoubtedly not have righted themselves." The fact that the efforts of the teachers and principal during the first year were unsuccessful illustrates the value of a conference with parents to ascertain facts relative to the child's home life and also the value of a test of the type represented by the Downey Individual Will-Temperament Test. These procedures are not necessary in all cases, but frequently they are essential for a satisfactory diagnosis.

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[1] Reavis, *op. cit.*, p. 91.

[2] *Ibid.*, pp. 114f.

[3] *Ibid.*, pp. 129–56.

In another case reported by Reavis a potent cause of unsatisfactory school work was the pedagogical error in the primary school of requiring the pupil to learn to write with his right hand when he exhibited a decided preference for the use of the left.[2] Although this pupil appeared to be in normal physical condition and enjoyed good health, "his fundamental muscles were under-developed and the finer adjustments of accessory muscles required in writing were immature."

**Diagnosis of achievement.**—Achievement is a composite of many elements.[3] For example, in the study of arithmetic the child acquires a large number of abilities rather than a single arithmetical ability. He may learn to do certain types of examples well but for some reason fail to do other types satisfactorily. A pupil may be a "good speller" in general, but habitually misspell certain words. A pupil's achievement is seldom uniform. The achievement of the typical pupil involves a number of deficiencies, some of which are important. Hence there is need for diagnosing pupils with reference to their achievement. Most teachers make some attempt to discover the deficiencies of their pupils; but in order to be efficient in this phase of teaching a systematic procedure is necessary.

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[1] See page 332.

[2] *Ibid.*, p. 315.

[3] See pages 303f.

For the field of arithmetic, Buswell and John[1] have prepared a series of tests, called "work sheets," and a diagnostic sheet for convenience in recording the nature of the errors made.[2] The examples of the tests were selected after an extended study of pupils' errors. They are designed to afford adequate opportunity to a pupil to demonstrate his arithmetical abilities.

W. S. Gray[3] has pointed out that "there are striking differences in the accomplishments of children who encounter difficulties in reading." Achievement in reading is not a single unitary ability, but rather a combination of several abilities. Consequently, detailed measurement in reading is likely to reveal a variety of causes of unsatisfactory achievement on the part of the different members of a class. Gray[1] lists fourteen possible causes of failure and points out that there are many more. Since similar conditions probably prevail in other subjects, the teacher cannot make wise prescriptions of remedial instruction without detailed knowledge of the deficiencies of individual pupils.[2] No definite techniques, however, can be recommended for making the needed diagnoses. Several diagnostic tests have been devised and frequently these instruments can be used with profit. Some teachers have used a battery of standardized tests selected with reference to their needs. Other teachers have used informal tests and other means for securing significant information. An analysis of pupil responses to tests is frequently very helpful.

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[1] Buswell, G. T.—"Diagnostic Studies in Arithmetic," *Supplementary Educational Monographs*, No. 30. Chicago: University of Chicago, 1926. 212 pp.

[2] These materials together with a Manual of Directions are published by the Public School Publishing Company, Bloomington, Illinois.

[3] Gray, W. S.—"Remedial Cases in Reading: Their Diagnosis and Treatment," *Supplementary Educational Monographs*, No. 22. Chicago: University of Chicago, 1922, p. 7. This monograph contains detailed accounts of several case studies of pupils who were doing unsatisfactory work in reading. The reader who is interested in diagnosis in the field of reading will find this a very helpful reference. For a more comprehensive treatment of diagnosis see Gray, C. T.—*Deficiencies in Reading Ability: Their Diagnosis and Remedies.* Boston, D. C. Heath and Company, 1922. 420 pp. Chapters XVI to XX deal with the methods of diagnosis.

**Conferring with pupils.**—The effectiveness of a conference with a pupil depends largely upon the teacher's tact and skill. What attitude should the teacher maintain? What questions should he ask? How should he respond to the pupil's statements? What should he say to the pupil? No specific rules can be prescribed. In general the teacher should avoid talking too much. Although he may appropriately give suggestions and advice, he should avoid "preaching" to the pupil. The teacher should endeavor to get the pupil to talk frankly and freely. He may ask the pupil to explain why he is doing unsatisfactory work, to describe his methods of work, to tell of his interests, to tell how he spends his leisure, and the like. Usually specific questions are more helpful than general ones. When the pupil makes general statements he may be asked to give definite concrete illustrations. Appropriate tasks will exert a wholesome influence and frequently the responses of the pupil to these tasks will furnish the teacher with valuable clews to the cause of the pupil's difficulty.

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[1] Gray, *op cit.*, p. 21.

[2] A good reference to read in this connection is Loree, D. H.—"Methods of Discovering and Removing Specific Causes of Failure in Ninth-Grade Science," *School Review*, 34:377–86, May, 1926. Several individual cases are described.

**Conferring with parents.**—Frequently, valuable information about a pupil may be secured by conferring with his parents. Such a conference is especially helpful when a pupil appears to be handicapped by undesirable traits, such as lack of initiative, or inferiority complex.[1] As in the case of conferring with pupils, no specific rules can be given; but usually the teacher should prepare for the conference by assembling his information about the pupil and formulating questions relative to the puzzling aspects of the case.

**Educational and vocational guidance.**—The topic of guidance logically follows that of diagnosis, but the limits of this volume do not include the consideration of either educational or vocational guidance. Adequate treatment requires extended consideration of instructional procedures and of the purposes of education. Educational psychology is usually the first course in the professional training of prospective teachers, and the student of this volume should look upon his achievements as a foundation upon which he is to build in his study of methods of teaching and of the function and curriculum of our schools. As was pointed out in the Preface this volume has been written as the first of a series.

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[1] See the case study reported by Reavis described on pages 595-96.

## LEARNING EXERCISES FOR THE READER

1. Several of the preceding chapters, especially those on measurement, psychology of school subjects, and mental hygiene, include suggestions for the study of pupils. Examine these chapters and make a list of the suggestions you find.

2. Have you ever known of any pupils who were considered lacking in intelligence but who were really bright? If so, why were they misjudged by their teachers?

3. Why should teachers exercise caution in interpreting scores obtained by group intelligence tests?

4. Why is diagnosis of achievement important?

5. Discuss group versus individual methods of studying pupils.

6. Have you ever known a teacher who was skillful in conferring with pupils? If so, describe the method of this teacher.

7. Prepare a list of questions that might be used in a conference with a pupil to get him to reveal his study habits, interests, personality traits, and other factors that would be helpful in understanding him as a learner.

8. Among the various teachers you have had, under which one do you regard your progress as having been least satisfactory? Can you mention facts about yourself with which this teacher was unacquainted, a knowledge of which would probably have rendered his or her instruction in your case more effective? How could this teacher have obtained these facts?

9. Describe methods suitable for schoolroom use for testing for visual and auditory defects. See WHIPPLE, G. M.—*Manual of Mental and Physical Tests*, Part I. Baltimore: Warwick and York, 1914, Chapter VI.

10. To aid the teacher in securing significant information about the pupils, what facts about each pupil should be included in the school record?

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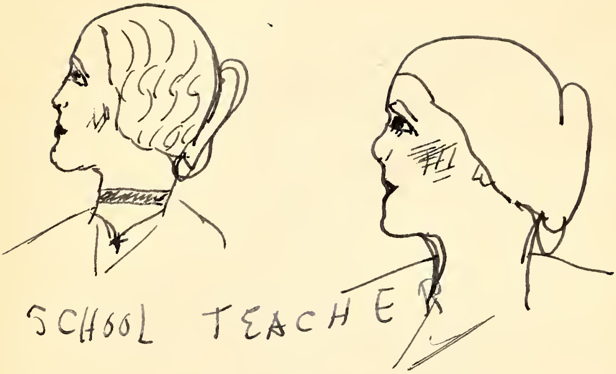

SCHOOL TEACHER

Harold L. Hirschauer
James M. Jones.

Limitations present. Test

1 Accuracy of test [illegible]
[illegible] ?

2 Validity [illegible]

3. Lack of [illegible]

4. [illegible]

[illegible]